STUDY OF THE ROLL AND PITCH TRANSIENTS IN CALM WATER USING THE SIMULATED PERFORMANCE OF THE XR-3 SURFACE EFFECT SHIP LOADS AND MOTIONS COMPUTER PROGRAM

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THESIS

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IN CALM WATER
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OF THE XR-3 SURFACE EFFECT SHIP
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by

Reinhard Fritz Menzel

December 1975

Thesis Advisor: A. Gerba Jr.

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by

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TABLE OF SYMBOLS AND ABREVIATIONS

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ABPB	vertical force due to plenum pressure
ACV	air cushion vehicle
ATAN	inverse tangent
CAB	captured air bubble ship
cont	continued
COS	cosine
cu	cubic
C.G.	center of gravity
C.P.	center of pressure
DELPI	initial plenum pressure
deg	degree
DSO	initial draft
F, f	force
FK....	roll moment
FM....	pitch moment
ft	foot
G, g	gravitational acceleration
GAM	specific weight
hp	horsepower
Hz	hertz
in	inch

kt	knot
lb	pound
NPS	Naval Postgraduate School
NSRDC	Naval Ship Research and Development Center
P	roll rate, rotational velocity about x-axis
PHI	roll angle
PI	pi
prd	period
psf	pound per square foot
psi	pound per square inch
PSI, ψ	yaw angle
Q	pitch rate, rotational velocity about y-axis
R	yaw rate, turn rate, rotational velocity about z-axis
rad	radian
R.D.	roll damping
RHO	specific density (water)
rms	root-mean-square
rpm	revolutions per minute
sec	second
SES	surface effect ship
sq	square
SQRT	square root
THETA	pitch angle

U	longitudinal velocity
USN	United States Navy
V	lateral velocity
VAL(1)	independent variable time
vs	versus
W	vertical velocity
x	horizontal distance in direction of motion
y	horizontal distance perpendicular to direction of motion
z	vertical distance

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I. INTRODUCTION

A. BACKGROUND

For a few years the Surface Effect Ship (SES) has been receiving increasing attention in the United States Navy (USN), and detailed studies have been undertaken since then. The two major categories of SES are the Air Cushion Vehicles (ACV) and the Captured Air Bubble Ships (CAB).

Whereas the weight of the ACV is entirely supported by the pressure differential in the plenum chamber all surrounded by flexible seals between the water surface and the hull structure, the CAB uses rigid sidewalls extending into the water and thus giving additional support to that of the captured air bubble. Some lift forces are made up by the flexible bow and stern seals as well as aerodynamic forces at higher speeds are usually taken into account.

The latter type of craft has become of primary interest to the USN for ocean going applications and led to the construction of several test crafts, among those the Aerojet-General 100-A, the Bell Aerospace Systems 100-B, both of about 100 tons displacement, and the XR-3 with approximately 3 tons displacement. This study will be concerned with the XR-3.

This ship was built by the Naval Ship Research and Development Center (NSRDC) in 1966 and tested for several years. In March 1970, the XR-3 was delivered to the Naval Postgraduate School (NPS), Monterey, California, for further investigations. After a digital computer simulation program for the 100-B test craft was developed by Oceanics, Inc., Leo and Boncal [Ref. 1] converted this program to represent the XR-3 test craft as there were substantial design differences between those two ships.

In December 1974, Forbes [Ref. 2] undertook a validation of the Loads and Motion computer program in calm water and introduced some modifications in various program subroutines. At the same time Finley [Ref. 3] refined the bow and stern seal subroutines and developed new fan maps in order to achieve more realistic air flow rates and thus an improved craft performance.

B. OBJECTIVES

The purpose of this thesis is the study of the pitch and roll response of the XR-3 Loads and Motions computer program in a comparison between the two modified versions of Refs. 2 and 3. Changes are introduced, where neccessary, with the idea to improve the computed pitch and roll behaviour. The final goal is to select an optimal model from the results obtained for future studies.

In order to ease the further discussion the computer models involved are named as follows:

Program 1 = computer simulation program used in Ref. 1
Program 2 = computer simulation program used in Ref. 2
Program 3 = computer simulation program used in Ref. 3

A users manual for the final program chosen is attached in Appendix A and should be read in conjunction with this text in order to better understand the subroutine programs and variables under discussion.

II. GENERAL DISCUSSION

A. ANALYSIS OF MOMENTS

The development of the equations of motion considering the craft to have six degrees of freedom will not be discussed here as it is well presented in Refs. 1 and 4. However, the forces and moments involved need some consideration. In general , various elements contribute separate forces to the different degrees of freedom and can be represented by:

$$F = F_{\text{bowl seal}} + F_{\text{stern seal}} + F_{\text{sidewalls}} + F_{\text{rudder}} + F_{\text{propulsion}} + F_{\text{waves}} + F_{\text{aerodynamic}} + F_{\text{airbubble}} + F_{\text{gravitational}}$$

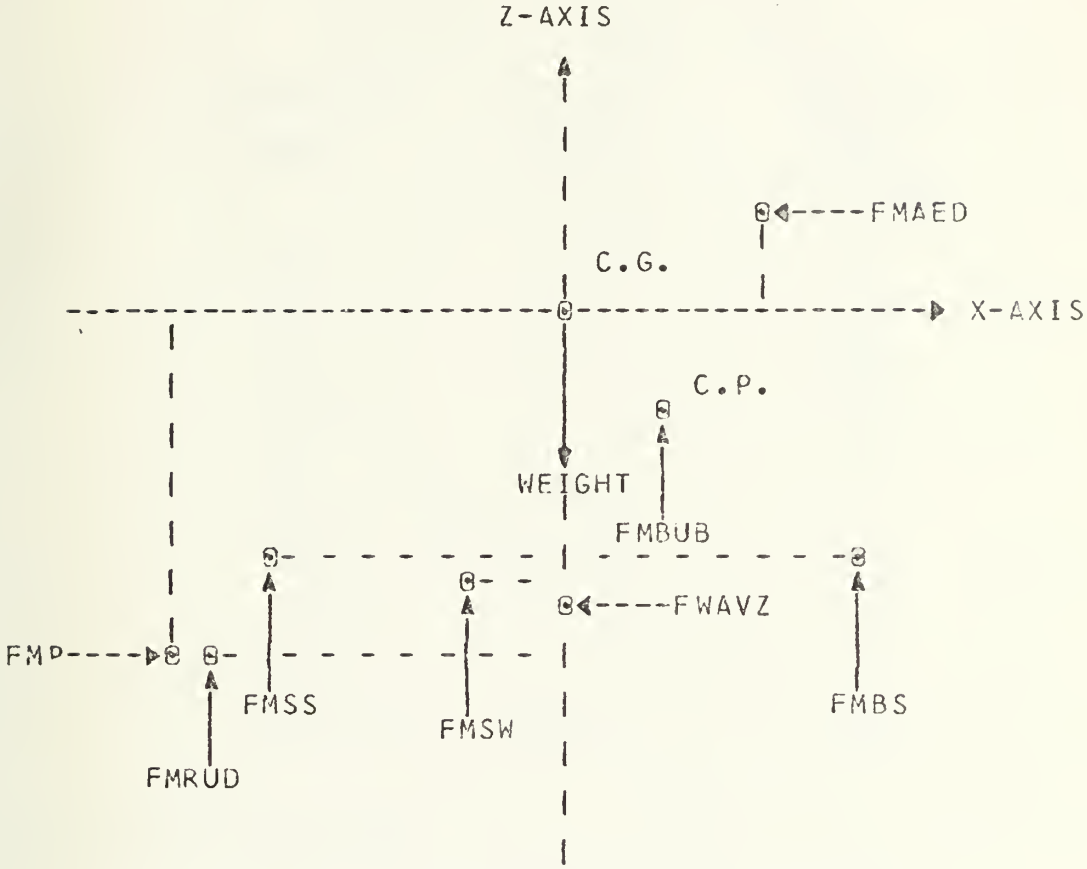
With respect to the local reference system the x- and z-components of the individual forces determine the moments about the lateral y-axis and, therefore, the final pitch angle at steady state. These moments are calculated in the various subroutine programs (see Appendix A) and then added up to give the net moment which eventually reduced to zero in calm water steady-state.

In figure 1 these moments for the XR-3 are shown in a schematic manner to indicate their predominant effect on the pitch behaviour. Counterclockwise acting moments are considered positive by convention.

In a similar fashion, the moments around the x-axis determine the roll angle, which - provided the craft is symmetric about its longitudinal axis including weight distributions - tends to be zero in calm water. In order to give an impression of the magnitude ratios the rounded moment values for a typical straight run at 20 knots are given in table 1. These figures were obtained from program 2

FIGURE 1

MOMENTS IN LATERAL PLANE



COUNTERCLOCKWISE ACTING MOMENTS ARE POSITIVE.

LISTING OF MOMENTS

FMBS = MOMENT DUE TO BOW SEAL FORCES

FMSS = MOMENT DUE TO STERN SEAL FORCES

FMSW = MOMENT DUE TO SIDEWALL FORCES

FMRUD = MOMENT DUE TO RUDDER FORCES

FMP = MOMENT DUE TO THRUST OF PROPELLER

FMAED = MOMENT DUE TO AERODYNAMIC FORCES

FMBUB = MOMENT DUE TO LIFT FORCES OF AIR BUBBLE

FWAVZ = MOMENT DUE TO BUBBLE WAVE MAKING DRAG FORCES

FMWAV = MOMENT DUE TO WAVE FORCES
(EQUALS ZERO IN CALM WATER)

in its original version.(See also D.1.a.)

Table I

Summary of Moments (pitch)

(Program 2, original version)

Component Name	Positive Moment (lb-ft)	Negative Moment (lb-ft)
FMBS	705	---
FMSS	---	112
FMSW	---	3827
FMRUD	---	85
FMP	1147	---
FMAED	645	---
FMBUB	1805	---
FWAVZ	---	278
FMWAV	0	---
Summary	4302	4302

B. INITIAL CONDITIONS

Reference 2 points out that the choice of the program initial conditions is somewhat critical. If they are not close to the steady state values the imbalance in forces generated within the program will cause an execution stop due to an improper integration step size. Thus a tedious method with elaborate curves families was used in Ref. 2 to develop the correct data including a proper integration step size.

References 2 and 3, unfortunately, give no information about the effect of their program changes on the initial conditions nor are the values used for the simulation runs completely listed. Refference 2, however, presents some

steady state values for straight runs with pitch angles considerably larger than those reported by Olmstead[Ref. 5] which come closer to the values observed with the present craft configuration.

As further data were not readily available, the initial conditions given in Ref. 1 were chosen and are repeated in table II. The first trial runs with programs 2 and 3 showed in both cases that the disturbances introduced were well within the limits of the programs' capability. Steady state was reached after an avarage of less than ten seconds simulated run time of the craft.

Table II

Initial Conditions

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.72	6.60	24.86	504.0	0.0
12.5	1.31	6.50	24.86	420.0	0.0
15.0	0.94	6.35	24.86	392.0	0.0
17.5	0.60	6.15	24.86	398.0	0.0
20.0	0.29	5.98	24.86	424.0	0.0
22.5	0.13	5.78	24.86	464.0	0.0
25.0	0.09	5.56	24.86	512.0	0.0
27.5	0.06	5.30	24.86	568.0	0.0
30.0	0.05	3.02	24.86	626.0	0.0

C. CRAFT DATA

The following data were used throughout the entire study unless otherwise specified. The numbers in parentheses indicate the block numbers under which the values are read into the program (subroutine INCON). These names are used in this study without further explanation which can be looked

up in Appendix A.

XS(2)	=	10.05	feet forward of transom
XLTOT(3)	=	24.7	feet
XLSW(4)	=	21.9	feet
XSSI(5)	=	3.97	feet forward of transom
XLF(5)	=	4.06	feet
XBSI(6)	=	23.44	feet forward of transom
XBF(6)	=	4.06	feet
XLBW(7)	=	20.0	feet
XPWV(7)	=	17.2	feet forward of transom
XL(7)	=	20.0	feet
XCPO(7)	=	10.4	feet forward of transom
XPO(8)	=	-1.275	feet forward of transom
XRO(9)	=	-1.125	feet forward of transom
XLAERO(10)	=	20.0	feet
RSPAN(9)	=	1.21	feet
YSW(4)	=	5.37	feet from centerline
AVBMSW(4)	=	0.5	feet
WIDTH(7)	=	10.0	feet
YPO(8)	=	5.55	feet from centerline
YR(9)	=	5.55	feet from centerline
BEAM(10)	=	10.0	feet
ZS(2)	=	2.54	feet above keel
ZSSI(5)	=	1.875	feet above keel
ELMAXS(5)	=	1.875	feet (Program 3 only)
ZBSI(6)	=	1.875	feet above keel
ELMAXB(6)	=	1.875	feet (Program 3 only)
CENCAB(6)	=	1.875	feet (Program 3 only)
XBBW(7)	=	10.0	feet
BUBHGT(7)	=	1.915	feet
ZPO(8)	=	-0.604	feet above keel
ZRO(9)	=	-0.208	feet above keel
WEIGHT(2)	=	6050.0	pounds
THSSI(5)	=	63.4	degrees (Program 2 only)

```
THBSI(6)   =   63.4   degrees (Program 2 only)
AIXX(2)    =2870.0    slug-square feet
AIYY(2)    =9320.0    slug-square feet
AIZZ(2)   =10580.0    slug-square feet
AIXZ(2)   =-2800.0    slug-square feet
ALEAK(5)   =  26.0    square feet
DPSS(5)    =   1.0    pounds per square foot
DPBS(6)    =   1.0    pounds per square foot
BLEAK(6)   =   0.1    square feet
RAREA(9)   =   0.68   square feet

CFSW(4)    =   0.7
CDSW(4)    =   1.28
CFSS(5)    =   0.9
CFBS(6)    =   0.9
FNCRIT(7)  =   0.556
RASPR(9)   =   2.15
RTC(9)     =   0.167
STHS(16)   =   0.01
STHP(16)   =   0.01
```

III. PITCH ANGLE
(Steady State Conditions)

A. PROGRAM 2

1. Initial Runs and Evaluation

Using the initial conditions from Ref. 1 the steady state values of program 2 were obtained as reported in table III. Whereas the values for draft, plenum pressure and thrust lay in the expected range, the pitch angle increased with higher speed. This tendency was the first point for a more thorough investigation of the changes made in Ref. 2.

Table III

Steady State Conditions
(Program 2, original version)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.74	8.18	24.45	405.16	0.0
12.5	1.71	8.10	24.46	356.42	0.0
15.0	1.74	7.97	24.46	352.44	0.0
17.5	1.80	7.78	24.46	373.96	0.0
20.0	1.90	7.54	24.46	411.18	0.0
22.5	2.01	7.23	24.46	457.84	0.0
25.0	2.15	6.87	24.46	509.57	0.0
27.5	2.29	6.45	24.46	560.98	0.0
30.0	2.47	6.01	24.33	613.63	0.0

The simulation derived in Ref. 1 contained a speed dependent correction term for the x-coordinate of the center of pressure which was assumed to move aft with increasing speed and thus reducing the pitch angle [Ref. 6]. This term had been removed in Ref. 2 with the assumption that due to

the existance of a pressure wave [Ref. 7] an incremental wedge of volume has to be added to the plenum volume which varies with speed and moves the center of volume aft with increasing speed. The according changes introduced in subroutines RHS and WAVES were expected to take care of the correct pitch angles.

In order to study the effect of the previously mentioned change - here called water slope correction - the moments of the original program 2 were recorded as shown in table I. Then, one after the other, the water slope correction terms in the subroutines INCON, BOWSL, STNSL, RHS and SIDEWL were removed. Due to the nature of these terms a different pitch angle could be expected only at lower speed. In all cases, at 10 knots for example, the angle was lower than the original value. The biggest change in the corresponding moment could be observed in the bow seal routine when the pitch angle dropped to 1.21 deg.

The overall results from these first trial runs indicated that the water slope correction provided a neccessary curvature in the pitch curve over the speed range of interest pointed out in the following investigation, but could not take care of declining angles with increasing speed.

2. <u>Selection of Pitch Angle Curve</u>

As pointed out in Ref. 5 the actual pitch angles of the XR-3 are dependent on the loading condition of the craft and the seal adjustments. Several curves are presented from which the following two were chosen:

- The upper limit for the pitch angles was set by the so-called "ideal" curve with theoretically derived values.
- The lower limit was given by the so-called "three turns" curve. These values were actually measured on the craft

after the seals were adjusted with "three turns" by means of a spindle.

The values for these two curves and the original pitch angles of program 2 are shown in table IV and graphed in figure 2. Additionally the values needed later as initial conditions were plotted using subroutine COLFIL after modifying for thrust as a variable (plots 1 through 4). From these data the neccessity to correct the program under discussion was obvious.

Table IV

Steady State Pitch Angles

(Original version)

Speed (knots)	"Ideal" (deg)	"Three Turns" (deg)	Program 2 (deg)
10.0	2.45	1.45	1.74
12.5	2.15	1.10	1.71
15.0	1.70	0.80	1.74
17.5	1.25	0.65	1.80
20.0	0.85	0.40	1.90
22.5	0.60	0.30	2.01
25.0	0.30	0.25	2.15
27.5	0.25	0.22	2.29
30.0	0.22	0.20	2.47

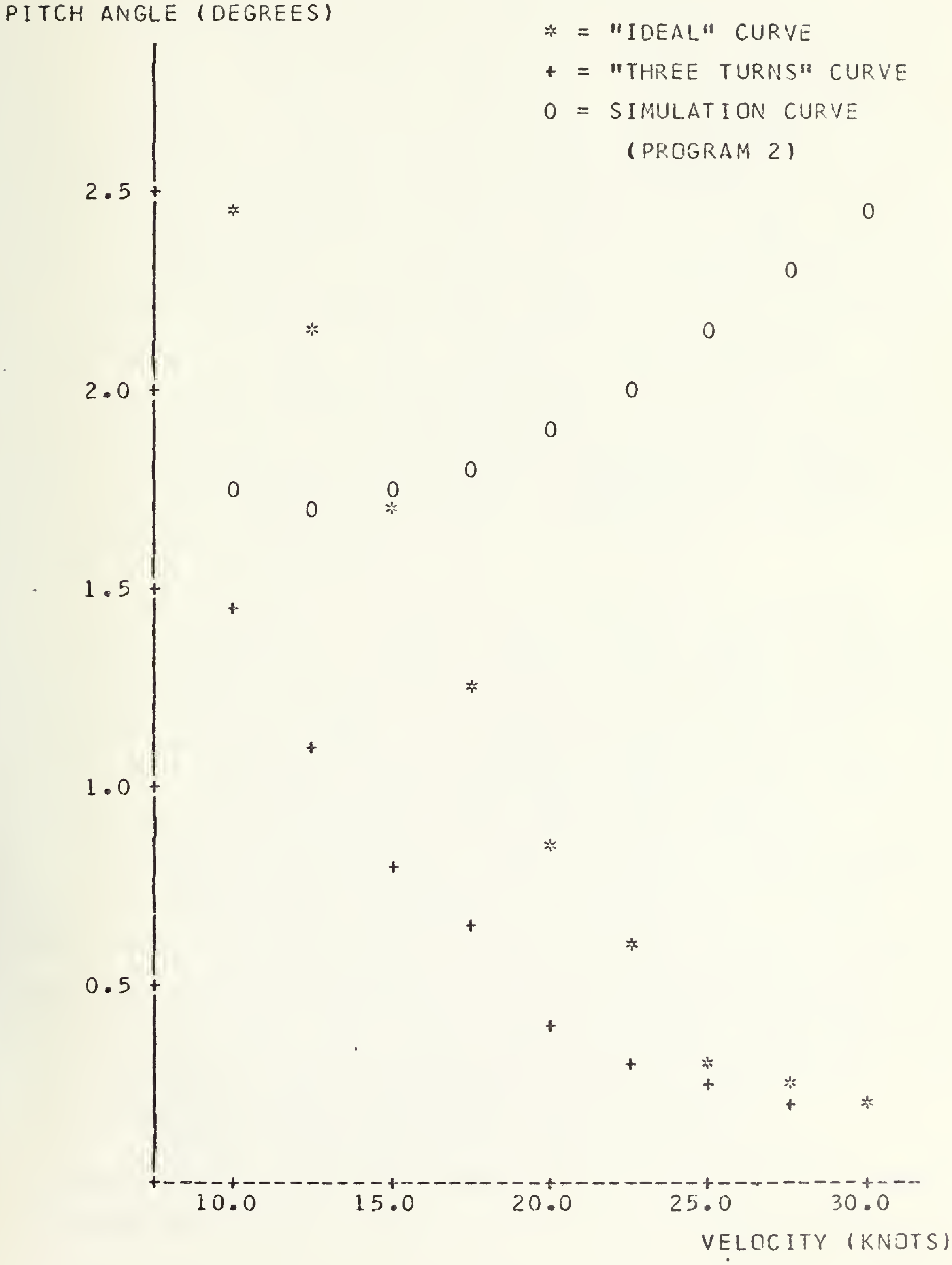
3. Changes and Justification

First Change:

In order to achieve the desired pitch angles one or more moments as listed in table 1 had to be changed. As it was not intended to modify the modeling of the individual components like seals, sidewalls, rudder, propulsion system or fans, which surely would endanger a qualitative comparison with program 3, the only moments left were FWAVZ

FIGURE 2

STEADY STATE PITCH ANGLES



and FMBUB assuming the aerodynamic forces found in wind tunnel test being correct.

In figure 3 the corresponding forces and their points of attack are shown together with the according equations as used in the subroutines INCON and RHS. Following the calculations it can be seen that the moment FWAVZ is generated by the bubble wave making drag FXPWAV, which basicly is a function of the craft's velocity and weight. PBBAR can be considered constant similar to the pressure values in table III. In order to reach smaller pitch angles at higher speed FXPWAV would have to be increased substantially with the result that the water slope correction term WATSLP and the thrust of the craft attained unrealistic values at lower velocity where the pitch angle tends to become negative as well as unforseeable changes in the dynamic response may be introduced. Therefore this possibility was rejected.

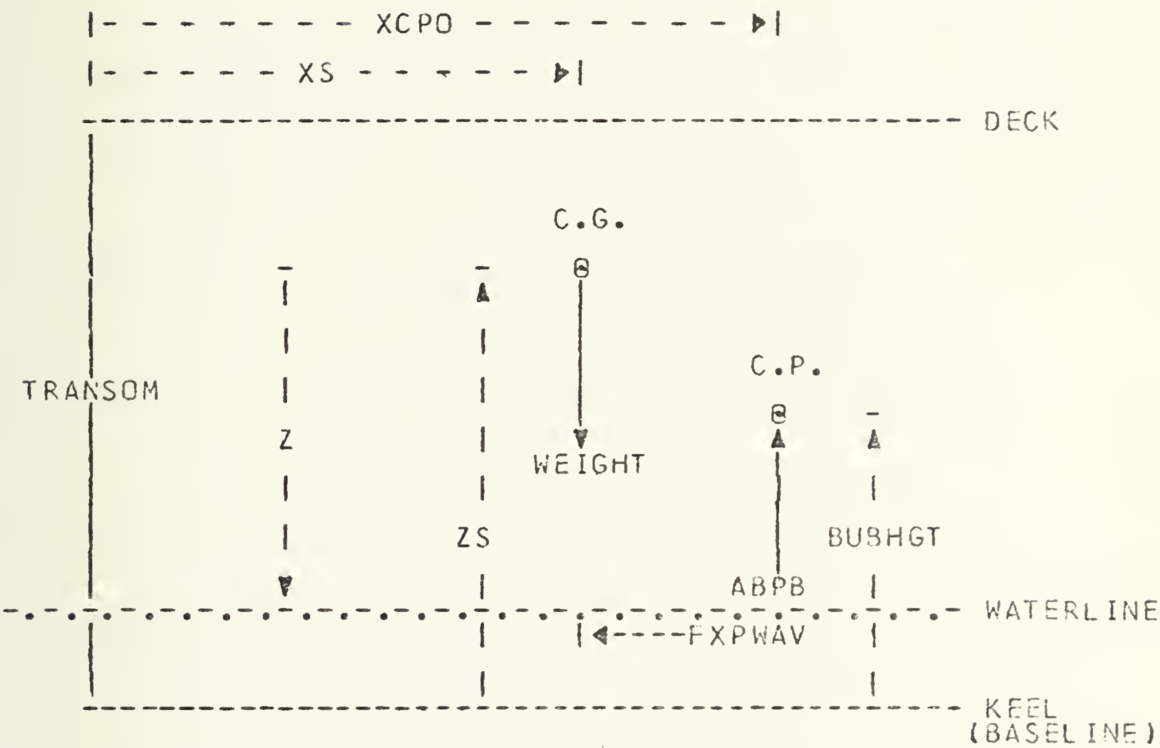
As mentioned before the plenum pressure can be considered constant. So the moment left for a possible pitch correction, FMBUB, could be used in this sense only by changing its lever, XCP, in a speed dependent manner. The method to determine the neccessary shift of the center of pressure (C.P.), in general, followed that outlined in Ref. 1, the resulting values are given in table V and graphed in figure 4. During this procedure it was tried to match the pitch angles of the "three turns" curve. It can readily be seen that there is an almost linear relationship between the location of C.P. and the craft's velocity. The following linear function used to approximate these data points was then included in the subroutines RHS and WAVES :

XCPU = XCP - 0.034*U*0.5921 + 0.3

This new variable XCPU was used in the force and moment calculations.

FIGURE 3

FORCES AT C.G. AND C.P.



RELATED CALCULATIONS:

1. IN SUBROUTINE INCON:

```
- - -
PWCON=4.*WEIGHT/(RHO*G*XLBW)
FNCON=SQRT(G*XLBW)
- - -
XCP=XCPO-XS
ZCP=ZS-BUBHGT
- - -
U=UO*1.6878
PBBAR=DELPI
- - -
```

2. IN SUBROUTINE RHS:

```
- - -
FN=U/FNCON
CF=.37/(FN**1.5655981)
FXPWAV=-PWCON*PBBAR*CF
WATSLP=-FXPWAV/WEIGHT
- - -
FMBUB=ABPB*(XCP-THETA*Z)
- - -
FWAVZ=-FXPWAV*ZS
- - -
```

FIGURE 4

SHIFT OF CENTER OF PRESSURE

(PROGRAM 2)

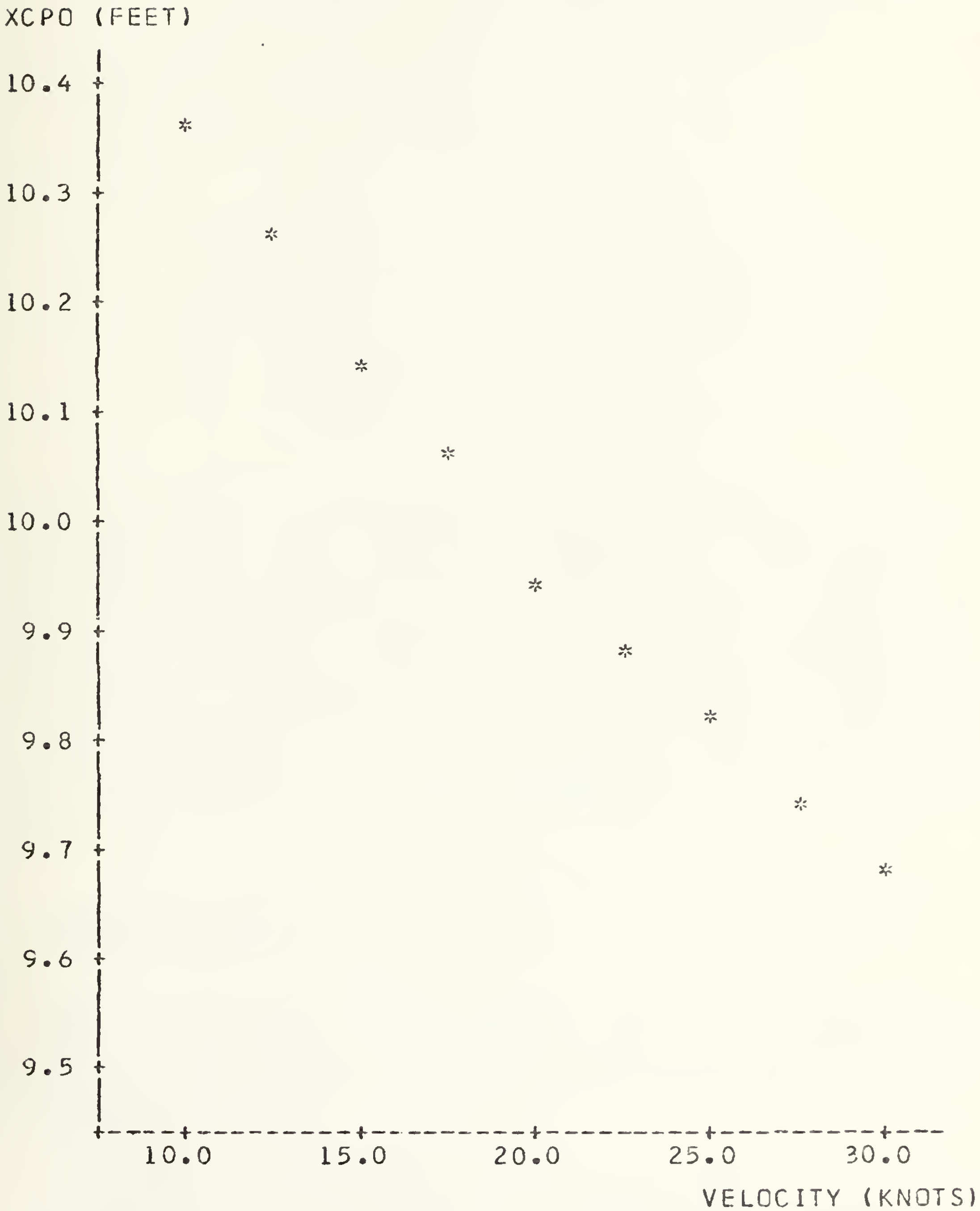


Table V

Position of Center of Pressure

(Program 2, first change)

Speed (knots)	XCPO (feet)
10.0	10.36
12.5	10.25
15.0	10.14
17.5	10.06
20.0	9.95
22.5	9.87
25.0	9.81
27.5	9.75
30.0	9.68

The updated steady state values are contained in table VI. Whereas the pitch angles approached the destinated values in a satisfactory way, the greater draft (and consequently increased thrust) especially at higher speed may be regarded a setback. But as at this point it could be seen that a similar correction would be neccessary for program 3 its impact on this comparison was not considered crucial.

Second Change:

When calculating the moment due to the bubble wave making drag, FMBUB, program 2 contains a correction term for XCP in subroutine RHS :

```
FMBUB = ABPB*(XCP-THETA*Z)
```

As Z is used as a negative quantity (computed in subroutine INCON : Z= -ZS+DSO/12.0), FMBUB would increase with larger pitch angles provided ABPB does not vary much. Under the small angle assumption for the pitch angle THETA this lever

change generally is true, but in the above situation does not represent the position of C.P. of the XR-3. Presumably the location of C.P. on the 100B craft was almost underneath the center of gravity (C.G.), with ZCP much larger than XCP and nearly equal to Z. In the case of the XR-3 for the given data ZCP is only twice as large as XCP and considerably smaller than the average Z.

Table VI

Steady State Conditions

(Program 2, after first change)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.45	8.33	24.34	405.84	0.0
12.5	1.17	8.18	24.46	358.56	0.0
15.0	0.94	8.10	24.46	357.52	0.0
17.5	0.76	7.99	24.46	383.74	0.0
20.0	0.61	7.86	24.46	428.38	0.0
22.5	0.48	7.71	24.46	486.60	0.0
25.0	0.37	7.54	24.46	555.25	0.0
27.5	0.27	7.37	24.46	632.21	0.0
30.0	0.19	7.18	24.46	715.64	0.0

Therefore this term was removed and by the following function replaced:

```
XCPC = SHXYAX(XCPU, ZCP, THETA, PI)
```

This corrected x-coordinate was than reintroduced in the subroutines WAVES and RHS, the letter using the new value to calculate the moment:

```
FMBUB = ABPB*XCPC
```

The function SHXYAX - shift of x-coordinate due to rotation around the y-axis - is kept quite general in order to enable its use for other cases. In this subprogram the radius of

the path that discribes the movement of C.P. is calculated and its angle with the X-axis.

```
      FUNCTION (X, Z, ANGYAX, PI)
      H = SQRT (X**2+Z**2)
      IF (X.EQ.0.0) GO TO 1
      ARG = Z/X
      ANGOLD = ATAN(ARG)
```

The IF-statement avoids the calculation of ARG with a zero denominator. Depending on the sign of ANGOLD the true angle between H and X-axis is computed and the (pitch) angle ANGYAX subtracted:

```
      IF (ANGOLD.GE.0.0) GO TO 2
      ANGNEW = ANGOLD + PI -ANGYAX
      GO TO 3
    1 ANGNEW = PI/2.0 - ANGYAX
      GO TO 3
    2 ANGNEW = ANGOLD - ANGYAX
```

The corrected x-coordinate is finally found by:

```
    3 SHXYAX = H*COS (ANGNEW)
```

After introduction of this change the simulation program was re-run and the final results recorded in table VII and figure 5. Though this second change had only little influence on the steady state conditions as measured it was felt that it should stay in the simulation program because of its possible effect on the dynamic response where larger pitch angles may occur.

The new moments are given in table VIII. They were attained under the same run conditions near steady state as those of table I. Due to the now negative moment FMBUB (a total shift by about 2000 lb-ft) and smaller pitch angle the bow seal increased its moment considerably whereas the sidewalls reduced their effect as generally could be expected.

FIGURE 5

STEADY STATE PITCH ANGLES

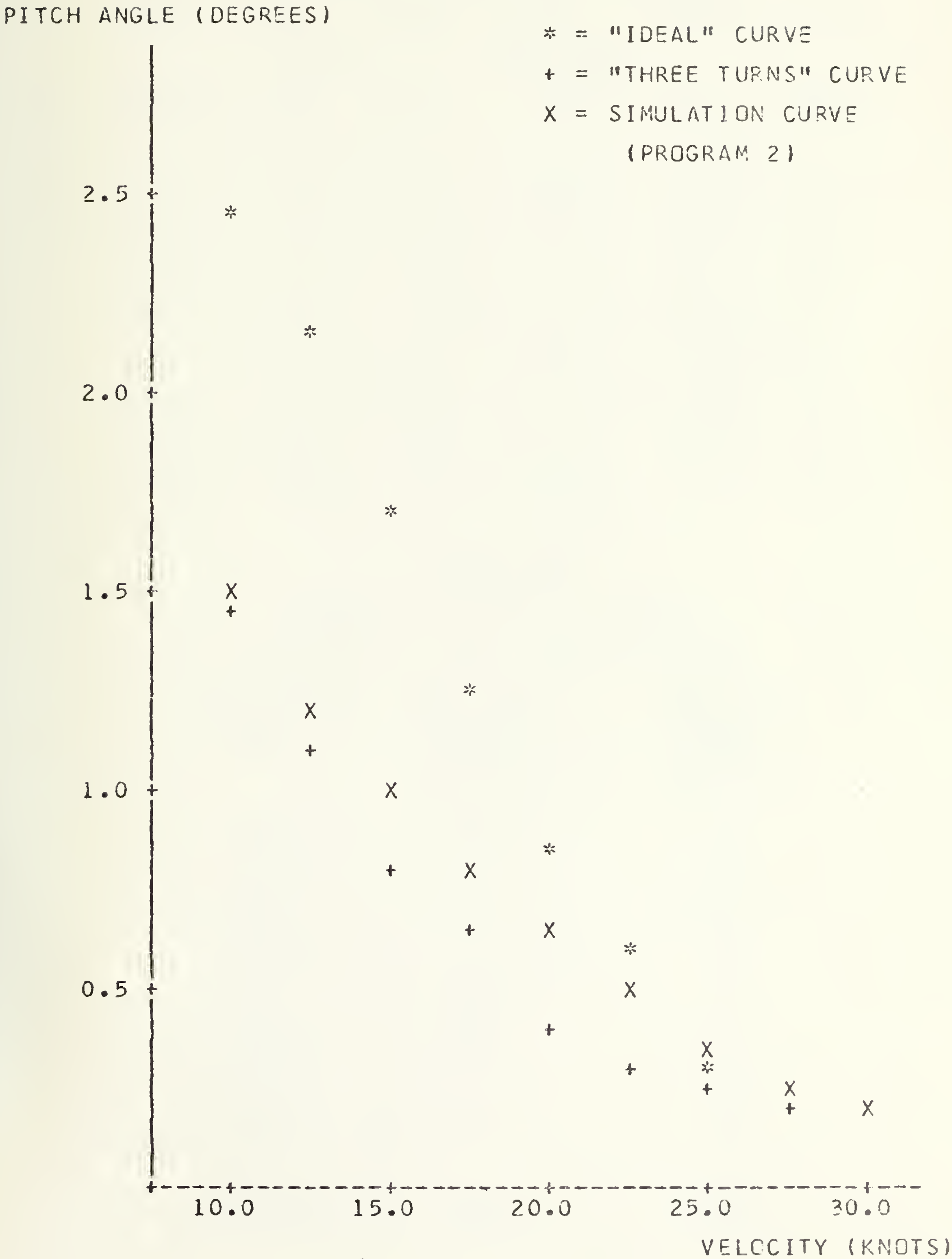


Table VII

Steady State Conditions

(Program 2, after second change)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.50	8.31	24.36	405.74	0.0
12.5	1.21	8.17	24.45	358.42	0.0
15.0	0.98	8.10	24.46	357.38	0.0
17.5	0.79	7.99	24.46	383.56	0.0
20.0	0.63	7.85	24.46	428.20	0.0
22.5	0.49	7.71	24.46	486.38	0.0
25.0	0.37	7.54	24.46	555.02	0.0
27.5	0.27	7.37	24.46	631.98	0.0
30.0	0.20	7.18	24.46	715.42	0.0

Table VIII

Summary of Moments (pitch)

(Program 2, after second change)

Component Name	Positive Moment (lb-in)	Negative Moment (lb-in)
FMBS	1227	---
FMSS	---	81
FMSW	---	2619
FMRUD	---	83
FMP	1292	---
FMAED	650	---
FMBUB	---	109
FWAVZ	---	277
FMWAV	0	---
Summary	3169	3169

For the further comparison with program 3 the variables pitch angle, z-displacement, plenum pressure and thrust (starboard) versus time were plotted (plots 5 through 8) starting from the initial conditions as given in table II. Although in this part of the study the steady state conditions were of primary interest, some general conclusions concerning the dynamic behaviour already can be drawn. Plot 5 additionally indicates a more damped pitch response due to the first change.

Table IX

Steady State Conditions
(Program 3, original version)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	0.94	6.68	24.88	521.9	0.0
12.5	0.68	6.48	24.83	428.0	0.0
15.0	0.47	6.22	24.82	392.8	0.0
17.5	0.28	5.94	24.81	389.6	0.0
20.0	0.11	5.65	24.81	406.3	0.0
22.5	0.69	6.23	24.86	449.3	0.0
25.0	0.63	6.03	24.86	492.7	0.0
27.5	0.56	5.80	24.87	543.6	0.0
30.0	0.48	5.46	24.98	596.7	0.0

Note: XS = 10.08 feet

B. PROGRAM 3

1. Initial Runs and Evaluation

The basic craft data used in Ref. 3 fortunately did not differ from those of Ref. 2 exept that the center of gravity (C.G) was positioned slightly more forward. The

results of the first simulation runs are summarized in tables IX and X under application of the same initial conditions, the pitch angles are graphed in figure 6. It was immediately apparent that in this program version, too, a correction of the pitch angle was neccessary before a first comparison could be made.

Table X

Steady State Pitch Angles

(Program 3, original version, and Ref. 5)

Speed (knots)	"Ideal" (deg)	"Three Turns" (deg)	Program 3 (deg)
10.0	2.45	1.45	0.94
12.5	2.15	1.10	0.68
15.0	1.70	0.80	0.47
17.5	1.25	0.65	0.28
20.0	0.85	0.40	0.11
22.5	0.60	0.30	0.69
25.0	0.30	0.25	0.63
27.5	0.25	0.22	0.56
30.0	0.22	0.20	0.48

2. Changes and Justification

First Change:

A deeper look into program 3 revealed that in subroutine RHS the speed dependent shift of C.P. of Ref. 1 was still in use, whereas subroutines INCON, BOWSL and RHS already contained water slope correction terms like Ref. 2. As the existing calculation of the shift of C.P. was not satisfactory (the cause for the discontinuity at 22 knots remained unknown), these terms were removed from subroutine RHS and temporarily replaced by XCP. Additionally all water

FIGURE 6

STEADY STATE PITCH ANGLES

slope correction terms were revised or introduced in subroutines INCON, SIDEWL, RHS, BOWSL and STNSL as outlined in Ref. 2 in all details. Besides these changes the sign errors in subroutine PROP of Ref. 1 discovered by Ref. 2 were removed. A few trial runs, however, indicated only a negligible effect on the steady state values.

The results of the following simulations are reflected in table XI and figure 7. Despite the substantial changes made in Ref. 3 the overall tendency of the craft's pitch was almost identical with that of the original version of Ref. 2 and gave a further proof that the introduction of WATSLP alone was not sufficient to reach proper pitch angles.

Table XI

Steady State Conditions
(Program 3, after first change)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.97	7.05	24.90	405.67	0.0
12.5	1.82	7.11	24.92	347.40	0.0
15.0	1.75	7.09	24.91	334.35	0.0
17.5	1.75	7.02	24.84	347.26	0.0
20.0	1.78	6.93	24.71	377.27	0.0
22.5	1.85	6.76	24.61	415.74	0.0
25.0	1.97	6.49	24.51	459.64	0.0
27.5	2.12	6.13	24.45	504.41	0.0
30.0	2.15	5.93	24.35	555.91	0.0

Note: XS = 10.08 feet

Furthermore the center of gravity was re-positioned in order to match the conditions used in Ref. 2 (see II.C). This seemed permissable as both Refs. 2 and 3 used the same

FIGURE 7

STEADY STATE PITCH ANGLES

craft configuraticn and attained a shift of C.G. by adding some load to the craft. The new location mainly effected the pitch angle as indicated in table XII. The simulation curve of figure 7 was lifted up by an almost constant amount, but the general shape was not influenced. Therefore, the task remained to introduce an additonal correction term.

Table XII

Steady State Conditions

(Program 3, after first change and shift of C.G.)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	2.13	7.03	24.87	404.73	0.0
15.0	1.90	7.07	24.87	332.99	0.0
20.0	1.92	6.97	24.64	375.79	0.0
25.0	2.11	6.46	24.43	455.68	0.0
30.0	2.22	6.10	24.31	558.27	0.0

At this point the corresponding moments near steady state were recorded in table XIII which enables a direct comparison with program 2 under similar conditions (see table I). The reduced draft and plenum pressure as well as the changes made in Ref. 3 can be considered to account for the different moments FMBS, FMSS, FMSW and FMBUB. Again the same variables as in program 2 were output (plots 9 through 12).

Table XIII

Summary of Moments (pitch)

(Program 3, original version)

Component Name	Positive Moment (lb-in)	Negative Moment (lb-in)
FMBS	850	---
FMSS	---	324
FMSW	---	3694
FMRUD	---	83
FMP	1049	---
FMAED	651	---
FMBUB	1831	---
FWAVZ	---	280
FMWAV	0	---
Summary	4381	4381

Second Change:

The following modification was carried out the same way as the first one of program 2 (see III.A.3). The resulting values are represented in table XIV and graphed in figure 8. As a linear curve fit did not suffice a satisfactory approximation any longer a quadratic function was developed with final form:

XCPU=XCP+0.001975*(U*0.5921-30.0)**2-0.974

This new variable was used the same way to calculate force and moment. The resulting pitch angles besides the other steady state values are shown in table XV.

FIGURE 8

SHIFT OF CENTER OF PRESSURE

(PROGRAM 3)

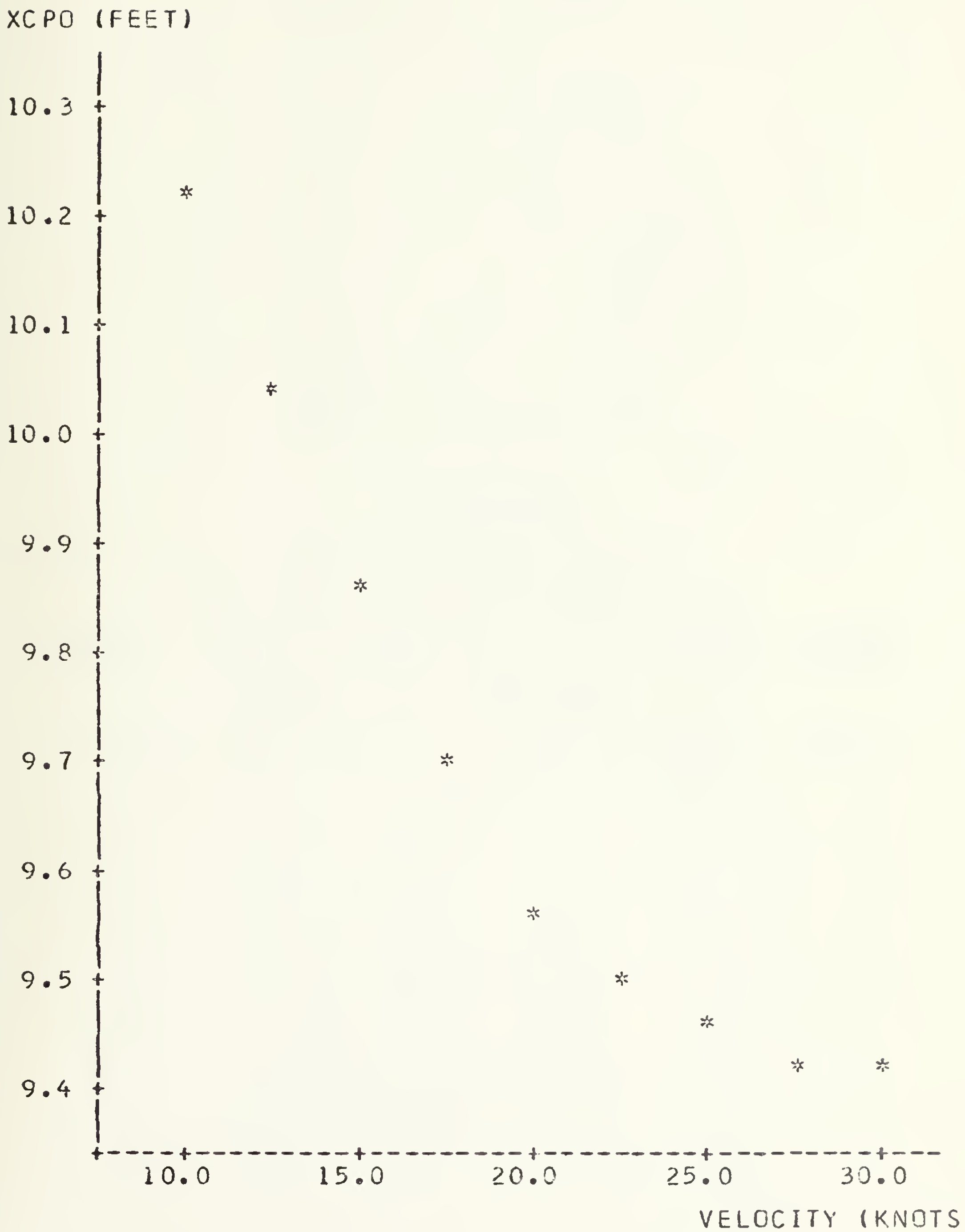


Table XIV

Position of Center of Pressure

(Program 3, second change)

Speed (knots)	XCPO (feet)
10.0	10.22
12.5	10.05
15.0	9.85
17.5	9.71
20.0	9.56
22.5	9.50
25.0	9.46
27.5	9.42
30.0	9.42

Table XV

Steady State Conditions

(Program 3, after second change)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.36	7.11	24.89	407.85	0.0
12.5	1.03	6.89	24.86	348.84	0.0
15.0	0.78	6.61	24.86	334.54	0.0
17.5	0.59	6.31	24.85	345.26	0.0
20.0	0.44	6.05	24.84	372.28	0.0
22.5	0.33	5.81	24.84	410.41	0.0
25.0	0.26	5.61	24.84	457.48	0.0
27.5	0.23	5.44	24.85	511.94	0.0
30.0	0.20	5.17	24.97	568.62	0.0

Third Change:

The last alteration reflected the shift of C.P. due to the craft's motion and was done by introducing the corresponding function SHXYAX which is described in detail in III.A.3. table XVI and figure 9 show the final results with pitch angles slightly off the anticipated values. As this was only marginal a new curve fit was not done, but once knowing the quadratic relationship it would be a relatively short and straight forward procedure (see V).

Table XVI

Steady State Conditions

(Program 3, after third change)

Speed (knots)	Pitch angle (deg)	Draft (in)	Plenum pressure (psf)	Thrust (lb)	Rudder (deg)
10.0	1.38	7.16	24.84	407.95	0.0
12.5	1.05	6.93	24.84	384.90	0.0
15.0	0.80	6.64	24.84	334.64	0.0
17.5	0.60	6.33	24.84	345.32	0.0
20.0	0.45	6.06	24.84	372.36	0.0
22.5	0.34	5.82	24.84	410.52	0.0
25.0	0.28	5.62	24.84	457.54	0.0
27.5	0.24	5.45	24.84	512.04	0.0
30.0	0.24	5.30	24.84	568.60	0.0

Some of the new steady state moments have changed considerably as can be seen from table XVII. Due to the further aft moving C.P. most of the compensating moment is picked up by the bow seal. It must be notified that, in general, the total moments of the corrected program 3 were significantly larger than those of program 2 after

FIGURE 9

STEADY STATE PITCH ANGLES

modification and would have had greater effect on the shear forces and bending moments which are not considered in this simulation(see V). The listed variables were also plotted for comparison studies (plots 13 through 16).

Table XVII

Summary of Moments (pitch)

(Program 3, after third change)

Component Name	Positive Moment (lb-in)	Negative Moment (lb-in)
FMBS	2985	---
FMSS	---	257
FMSW	---	2060
FMRUD	---	83
FMP	1138	---
FMAED	651	---
FMBUB	---	2094
FWAVZ	---	280
FMWAV	0	---
Summary	4774	4774

C. COMPARISION AND RESULTS

Although the data so far obtained allowed some comparison and conclusions additional information was neccessary to demonstrate the basic differences between the two program versions. In table XVIII the interesting variables are listed which were obtained in typical runs at 20 knots after all changes mentioned had been introduced. Also the time histories for pitch angle, draft, plenum pressure and thrust (starboard) give a good basis for a qualitative evaluation.

Starting from these trajectories a significant difference

can be seen in the pitch angle oscillations and the damping factor which will be investigated more thoroughly in the following chapters. The higher thrust in program 2 is certainly due to the greater draft so that under these consideration both programs reached reasonable steady state conditions.

Table XVIII

Steady State Performance Data

(Modified programs 2 and 3)

Variables	Units	Program 2	Program 3
Speed	kt	20.0	20.0
Pitch angle	deg	0.63	0.45
Time constant	sec	3.36	3.06
Frequency of oscillation	Hz	0.48	0.89
Draft	in	7.85	6.06
Thrust	lb	428.20	372.36
Air flow rates			
Bow fans	cu ft/sec	125.3	20.3
Main fans	cu ft/sec	135.2	22.0
Stern fans	cu ft/sec	125.3	12.9
total	cu ft/sec	385.8	55.2
Fan power required	hp	17.61	2.55
Actual fan power	hp	---	8.93
Plenum pressure	psf	24.46	24.84
Leakage flow rates			
Bow seal	cu ft/sec	12.9	10.4
Sidewalls	cu ft/sec	0.0	0.0
Stern seal	cu ft/sec	372.9	44.8
total	cu ft/sec	385.8	55.2
Plenum volume	cu ft	288.17	318.75

Nevertheless, program 3 represents more realistic air flow and leakage rates in connection with the available

plenum volume as indicated in table XVIII (The difference in the voluaina basicly is a consequence of different draft and pitch angles, too). The changes introduced had negligible effect on the computation time in both cases, but program 3 needed slightly less CPU time due to its better damping factor.

IV. ROLL ANGLE
(Dynamic Response)

A. INITIAL RUNS AND EVALUATION

In order to study the dynamic behaviour of the simulation models several possibilities were given to introduce the neccessary disturbance. Regular or irregular sea states in tabular form or by superimposed sine waves could have been entered using subroutine WAVES. Another way was to change speed by means of a thrust map of data points converted into a time history in subroutine PROP. Finally rudder angles could have been applied following a straight run or by varying angles given as data points, too. The choice was determined primarily by the idea that besides the qualitative comparison of mathematical models a future validation of the results obtained should be made possible. Therefore, an easy-to-measure calm water situation was prefered. As additionally new changes effecting the roll damping were to be incorporated the excitation through the speed did not seem very promising. Once the steady state conditions being found and used for initialisation a step rudder input (or a steep ramp input to come closer to the real case) seemed the best solution offering a fine control of the disturbance magnitude.

At a speed of 20 knots -actually the corresponding initial thrust was kept constant - a rudder angle of 35 degrees was found to give easily observable pitch and roll angle excursions for both models whereas larger values eventually caused water contact with the top of the plenum chamber and stopped the program execution (controlled by subroutine SIDEWL).

The first simulated turns under these conditions were recorded in plots 17 through 24 for both programs

respectively (pitch and roll rates were changed into output variables in subroutine COLFIL and graphed in order to ease the estimation of damping factor ratios). As previously learned program 2 showed a less damped pitch angle, but its roll angle response - after removal of the superimposed low frequency component of undetermined origin - is slightly more damped than that of program 3. The speed dependent shift of XCPO therein may also be the cause for an increased tendency towards self contained pitch angle oscillation.

B. ORGANIZATION OF SUBROUTINE SIDEWL

Before the next changes are explained a short introduction into the subroutine program SIDEWL is presented in order to give a better understanding of the possibilities and limitations of these alterations.

The hydrodynamic and hydrostatic forces and moments acting on the sidewalls are found by application of slender body theory. This theory is based on motion of a foil in a viscous medium. The methods by which the lift and drag forces associated with moving underwater bodies are found are primarily linear in nature (Ref. 4 and 8), but heave, pitch, and roll motions cause the most significiant nonlinear variations. Additionally there are certain nonlinear terms due to cross-flow drag, which are important for the case of very low aspect ratio lifting surfaces as in the case of the XR-3 sidewalls. The sidewall forces will then be composed of terms due to sidewall buoyancy and slender body hydrodynamic reactions and the effect of cross-flow drag:

$$F_{\text{sidewalls}} = F_{\text{slender body}} + F_{\text{cross-flow drag}}$$

In subroutine SIDEWL first the draft of or the gap beneath the sidewalls is calculated. The draft/gap is found

for each X-direction section after it has been corrected for craft roll and pitch angles and waves including water slope effect. In the presence of gaps the total sidewall leakage area ALSW is computed by summing the products of gap heights and sidewall section lengths for both sidewalls.

In the following force and moment calculation the cross-flow drag terms and slender body theory terms are computed in separate sections and finally summed to give the total values. In the case of the roll moment FK this calculation is of the form:

FK = (FZH(2)-FZH(1))*YSW-ZS*FY+FKD

The slender body theory terms FZH for each sidewall (1=port side, 2=starboard) are given by:

FZH = -G*BC0-U*U*A33S*THETA-U*A33S*W+Q*U
*(A33S*XSS-BC2)-U*A33S*P*YLSW

where the expressions used are defined as follows:

BC0 = mass of displaced water by the jth sidewall element
A33S = vertical added mass of jth sidewall element
XSS = -XS
BC2 = total sidewall vertical added mass
YLSW = lateral distance of jth sidewall element from the centerline

These components are either calculated in the subroutine itself or looked up in the sidewall tables computed in subroutine SIDETAB. Further details concerning the set-up of these tables are described in Ref. 4, the resulting values are stored in COMMON-block WAVTAB. The total lateral force FY is defined by:

FY = FYH(1)+FYH(2)-FYD

It represents the hydrodynamic lateral forces plus the corresponding cross-flow drag component derived as follows:

FYH = -A22S*U*(V+XSS*R-ZS*P)

where A22S is the lateral added mass at the stern given by:

A22S = (RHO*.4*PI*DSS**2)/2

with DSS beeing the computed sidewall draft. The final term

FKD is entirely due to cross-flow drag on both sidewalls each of them defined by:

```
FKD = FYD*(ZS-DSWAV/2)
```

where FYD is the lateral force due to cross-flow drag and DSWAV is the draft of the jth sidewall section corrected for waves. In the computation of FK the lateral force FY is used without the drag component which is added later. In general it must be said that all forces more or less influence each other so that a change in the roll characteristics neccessarily must alter the pitch and yaw behaviour or vice versa as could be seen when intrducing the pitch angle corrections or in the first turn runs where the pitch angles increased significantly.

C. CHANGES AND JUSTIFICATION

The following changes were recommended by Bentson [Ref. 9]. They consisted of two major blocks and a minor addition carried out in subroutine SIDEWL. The letter dealt with the vertical added mass at the stern, A22S, which is recomputed for the case of negative pitch angles using the corrected draft at the bow, DRBOW:

```
DRBOW=DSS-(XX(J,N+1)-XSS)*THETA
IF(DRBOW.LT.0.0) DRBOW=0.0
A22S=(RHO*.8*PI*DSS**2)/2.
IF(THETA.LT.0.0) A22S=.8*RHO*PI*DRBOW*DRBOW/2.
```

XX is the longitudinal distance of the nth sidewall station from the bow. The factor .8 in the calculation of A22S was changed to .4 in order to remain consistent with the model given based on the definitions derived in Ref. 4. The effect of this change, however, was not observable because the simulated pitch angles were most of the time positive except a few small negative transient peaks.

The next major change was a correction of the vertical force FZH. As the outside edge of the submerged portion of

the sidewall is not vertical near the bow an additional upright force component is generated due to the deadrise projection of the lateral force FYH, in algebraic terms defined by the product of the lateral force and the cotangent of the deadrise angle (average angle between the horizontal and the inclined outside edge of the mentioned sidewall portion). In FORTRAN IV language the computation proceeds as follows:

```
      CTNDR=0.0
      IF(DSS.LE.0.0) GO TO 22
      CTNDR=(BS-BB(1))/DSS
      IF(THETA.LT.0.0) CTNDR=0.39391
   22 CONTINUE
      FZH(J)=FZH(J)+PM1*FYH(J)*CTNDR
```

BS and BB(1) are the lower and upper beam widths of the submerged sidewall portion, CTNDR stands for cotangent, and PM1 is a unity sign factor depending on the sidewall under discussion.

The last addition had the purpose to improve the roll damping of the model. It was developed from the idea that when the craft is rolling the sidewalls generate asymmetric waves depending also on speed which take energy out of the ship and, therefore, have a damping effect on the roll motion. Without discussing each single step of this rather involved change the general procedure was to evaluate new draft numbers corrected for these waves and from there to find correction terms for the vertical added sidewall mass BC2. The previously determined roll moment FK was finally adjusted by subtracting the resulting counter moments including an experimental factor. The complete change was done as follows:

```
      DSS=Z+ZS-XSS*THETA
      ZOR1=(SIGN(1.,DSS)+1.)/2.
      DSS=DSS*ZOR1
      DS=Z+ZS
```

```
DSR=DS-(XREF-XS)*THETA
ID=1.+(DSR*12.-SDS)/DDS
ID=MAX0(MIN0(ID,NDS),1)
DDSR=(ID-1)*DDS+SDS
ID1=MIN0(ID+1,NDS)
DID=(DSR*12.-DDSR)/DDS
BC2=AC2(1,ID,IP)
BC2=BC2+DID*(AC2(1,ID1,IP)-BC2)+DIP*(AC2(1,ID,IP1)
    -BC2+DID*(AC2(1,ID1,IP1)-AC2(1,ID,IP1)
    -AC2(1,ID1,IP)+BC2))
FK=FK-16.*YSW*YSW*BC2*P/PI
```

For the shear and bending moment calculations not contained in this program version the vertical force components of the individual sidewalls were also corrected:

```
FZH(1)=FZH(1)+8.*YSW*BC2*P/PI
FZH(2)=FZH(2)-8.*YSW*BC2*P/PI
```

Reference 9 finally indicated the option to include the calculation of the spray drag of the sidewalls when operating at high speed with minimum draft. Whereas this function originally was developed for the 100B craft with considerably smaller draft values down to one inch at about 80 knots the XR-3 operates with five to six inches or more and, therefore, the effect of the spray drag was considered negligible.

D. COMPARISON AND RESULTS

Starting with program 2 the new roll and pitch characteristica were recorded in plots 25 through 28. Besides a reduced overshoot of the pitch angle by about 20 per cent the roll angles reached only about half of their original peak values while the non-linearities of the sidewall changes became quite apparent. Therefore, the time constants could not but be estimated and seemed to have increased slightly for both motions. Although the overall

response could be considered an improvement "an order of magnitude difference in the roll damping value" as pointed out in Ref. 9 and meant for the Bell 100-ton test craft could not be experienced for this model.

For program 3, whose time histories were graphed in plots 29 through 32 the changes introduced were not as well favourable. The roll angle overshoot reduced only by 20 per cent whereas an equally diminshed pitch angle seemed considerably less damped and showed the increasing trend for self-contained oscillation as indicated earlier. However, it must be noticed here that program 3 originally was not quite as underdamped as program 2 and, therefore, could not be effected by these changes by the same amount.

In order to attain an optimal model based on the previous results and considerations the two major changes made in subroutine SIDEWL and their individual impact on the simulated performance were studied more thoroughly after introducing a few modifications. In the calculation of the vertical force due to deadrise projection of FYH the statement

```
FZH(J)=FZH(J)+PM1*FYH(J)*CTNDR
```

was replaced by the following expressions:

```
FZHOLD(J)=FZH(J)
FZHDRP(J)=PM1*FYH(J)*CTNDR*PROMO1
FZH(J)=FZH(J)+FZHDRP(J)
```

These statements allowed to print the individual force components if desired and to vary the component value due to deadrise projection by means of the program card deck using one of the modification settings (see Appendix A). Similary the roll damping computation was re-organized:

```
FKOLD=FK
FK=FK-PROM2*YSW*YSW*BC2*P/PI
FZH(1)=FZH(1)+PROMO2/2.*YSW*BC2*P/PI
FZH(2)=FZH(2)-PROMO2/2.*YSW*BC2*P/PI
```

Finally a WRITE-statement was added using PROMO3 as print switch for VAL(1), FZHOLD(1), FZHOLD(2), FZHDRP(1), FZHDRP(2), FKOLD, and FK. The influence of various settings of PROMO1 and PROMO2 - here simply called deadrise factor and roll damping factor - could be studied on the following plots 33 through 60, the meaning of the R.D. number is summarized in table XIX.

Table XIX

Listing of Damping Coefficients

(Program 3)

R.D. number	Deadrise Factor	Roll Damping Factor
1	1.	16.
2	2.	16.
3	1.	32.
4	3.	16.
5	1.	48.
6	0.5	16.
7	1.	8.
8	0.5	32.

Using program 3 in these simulation runs it could be shown that the response was improved by lowering the deadrise factor and increasing the roll damping factor as graphed in plots 57 through 60 under R.D. number 8. These values were chosen to indicate an approach method only, more extended simulations with a finer factor spacing could possibly result in an even better damped behaviour. This step, however, should be done in conjunction with a validation of this model in comparison with measured test data.

V. CONCLUSIONS AND RECOMMENDATIONS

A great deal of time - more than anticipated at the onset - was required for familiarization with the computer models and for the implementation of comprehensive and reasonable initial trim conditions. For future studies Appendix A and the example program printout as well as the presentation of many tabulated data may help to reduce this introductory phase effectively.

The simulated roll and pitch motions, in general, were improved although some of the changes made need further investigation in connection with validation tests which should be performed with program 3 as the presently more advanced version. In case of future changes effecting longitudinal and athwartships stability it is recommended that the shift of center of pressure is verified as outlined in Appendix A before concluding tests are undertaken.

These further studies may concentrate on the investigation of the moment due to the product inertia term AIXZ which has some importance in maintaining stability in roll and pitch for larger rudder angles. The use of the discrete mass distribution option (Block 2) can be helpful for this case.

Another field of interest can be the air pressure distribution in plenum chamber and both seals and its influence on transient motions.

Perhaps the most significant improvements may arise from a comprehensive study of the modelling of the sidewalls. Besides the calculation of the vertical force due to deadrise projection of the lateral force - the sidewall wetted surface shape of the Bell 100-ton craft is almost

uniform from bow to stern, whereas the XR-3 is more formed like a wedge widening at the stern - the impact of flat portions on the bottom of the sidewalls as indicated in Ref. 3 should be investigated as they become effective planing surfaces at higher speed (20 - 25 knots) but are not considered in the simulation program so far. The need to lower the computed cotangent value indicates that the present calculation of the deadrise projection does not enough consider these structural differences. A pitch down due to a more negative sidewall moment would also reduce the neccessary shift of the center of pressure and thus the destabilizing effect on the transient response.

APPENDIX A

SES MOTIONS AND LOADS PROGRAM

USERS MANUAL

(short form)

INTRODUCTION

This users manual is a short form of that given in reference (1) which should be referred to in case of severe programming difficulty and for a deeper study of the subroutine programs involved. The version given here reflects the changes made in the meantime by Refs. 2 and 3 and by the author of the thesis study the manual is attached to. Its objective is to introduce the reader to the general program flow, to the neccessary requirements to establish an own input deck for various types of craft runs and to the output options.

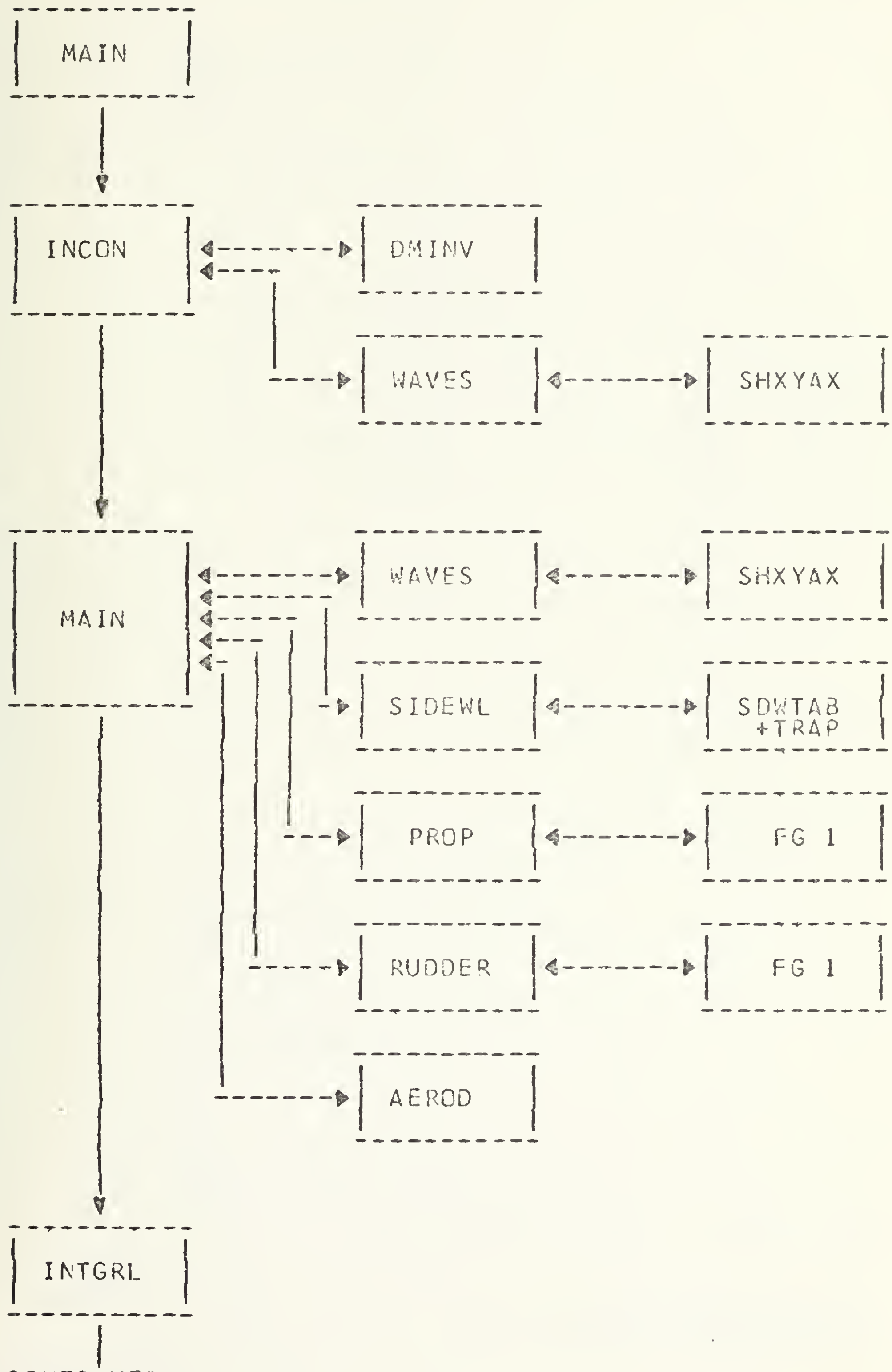
PROGRAM ORGANISATION

Within a given run the program proceeds as follows (see Figure 10):

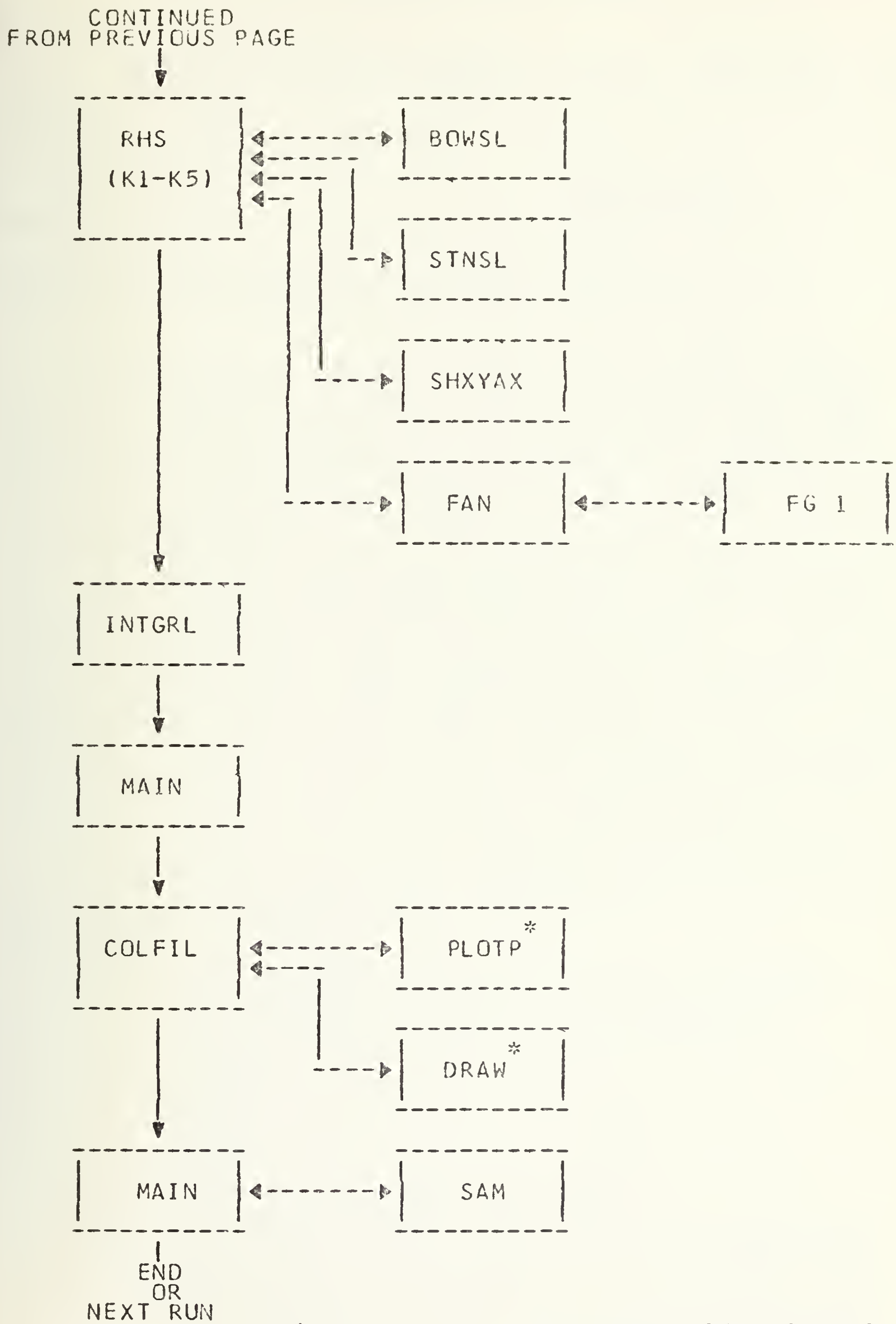
- First the main program calls the input and initialization subroutine INCON. The program then proceeds to calculate the motion time histories by calling the various modular subroutines and the integration routine for as many time steps as is neccessary to complete the run. During the course of the calculation the various subroutines will output those variables selected by the print option switches at the appropriate input print interval. In addition, data may be written on scratch files to be used for summarizing the output and doing bending moments and shear calculations (at the present time the shears and moments subroutine has been removed).
- When the run is completed, the program, depending on the options chosen, may then print and/or plot the output summary. After these steps are completed the main program returns to INCON to read data for the next case.
- The above procedure is repeated until all cases are finished.

FIGURE 10

PROGRAM FLOW DIAGRAM



CONTINUED ON NEXT PAGE



* = LIBRARY SUBPROGRAMS

PROGRAM REQUIREMENTS

As run on an IBM 360 computer under OS/360MVT version (Release 20.6), on W. R. Church Facility, NPS, the program requirements are as follows:

	TOTAL CORE
Program length	$201,456_{10}$
Core size requireed for execution	$250,000_{10}$

The total core required for a given step includes the program, system routines, data storage, etc. The time required to run a single case depends on the nature of the case and the length of time to be simulated. The ratio of required execution time to real time has been found to be as low as 1/3 for some calm water cases. Higher ratios occur where the transient curves are rather sharp as during the turn maneuvers in this study where 20 seconds run time needed about six minutes using FORTRAN G compiler. However, Mitchell [Ref. 10] found an average improvement of thirty-seven per cent CPU time by compilation in FORTRAN H.

The program currently uses the following FORTRAN Data Set Reference Numbers (Unit Numbers):

Unit Number	Usage
1	Scratch file for COLFIL plotting package.
2	Scratch file for lateral plane output
3	Summary
5	Input
6	Output
10-15	Sidewall Integral Table data
IBMF	Intermediate file containing time histories required by bending moment calculations. The unit number IBMF is read in using the 01501 input card not contained in the present program version.

INPUT

The input logic is subdivided into twenty-two "blocks". Each block being for a particular subroutine or function e.g. stern seal, sidewall, etc. Switching to the proper input block is done by means of a control tag on the input cards. Once control has been transferred to a particular block additional input may be read by specific format statements if necessary, however, the card which contains the control tag may also be used to input up to seven variables for the selected block. The format of the input card used for switching is described later, a sample data deck for the last simulation run (R.D. number 8) is copied at the end of this appendix.

The control tag used to transfer control to the appropriate block is of the form OMN where M and N are integer constants, i.e., if the control tag is 015 the program will go to statement 1500.

The option tag is loaded into a variable called IOPT and allows different branches of logic within a given input block. If no branches are used within the input block the option tag may be zero.

The input variables are stored in an array called TEMP and may be set to a given parameter by using an arithmetic replacement statement in the appropriate block (see various blocks in attached listing for examples). Print switches control the printing by each subroutine of its forces and moments. This option is very useful in debugging the program. Normally it provides too much output and is too cumbersome.

OUTPUT

The output generally consists of the following parts:

- The data input deck is first copied headed by the title "LISTING OF INPUT DECK". Each block and option is printed as actually punched onto the cards. These data are written in the main program prior to any test and, therefore, appear in all runs.
- After the data are read by subroutine INCON a more explanatory summary is output entitled "SES MOTIONS AND LOADS PROGRAM" followed by the description written in block 18. This table contains most of the input data and first computation results like inertia matrix and xx- and yy-arrays of sidewalls and seals. In cases of input errors a corresponding message follows and execution stops. Likewise all other problems preventing a proper completion of the current run are indicated at this place.
- If plots are requested they are either printed in the following part or, for CALCOMP plots, their titles and completion are summarized using subroutine COLFIL.
- In the final portion the tabulated variables as desired are summarized in one or two divisons followed by the message:

COMPLETED ALL RUNS

On the following page the possible variables for these plots or summaries are listed. A change to other variables needs only moderate program modifications in subroutines RHS and COLFIL, eventually in some others, too.

Listing of Output Variables

The names mentioned below are used in subroutine COLFIL, but may have different names in other subroutine programs.

Number	Name	Description
01	TIME	Independent variable time, seconds.
02	ETA	Wave height, feet.
03	Z	Z displacement, inches.
04	THETA	Pitch angle, degrees.
05	PB	Plenum pressure, psf.
06	BOWACC	Bow acceleration, ft/sq sec.
07	ACC	C.G. acceleration, ft/sq sec.
08	FANPWR	Fan power, horsepower.
09	PHI	Roll angle, degrees.
10	BETAS	Yaw angle, degrees.
11	ACCLAT	Lateral acceleration ft/sq sec.
12	U	Speed through the water, knots.
13	TRADIUS	Turn radius, feet.
14	VOLP	Plenum volume, cu ft.
15	X	X displacement, feet.
16	Y	Y displacement, feet.
17	QIN	Air flow rate in, cb ft/sec.
18	QOUT	Air flow rate out, cb ft/sec.
19	GFXXX	Net force in x direction, lb.
20	FXPWAV	Wave force in x direction, lb.
21	THSTS(1)	Starboard thrust, lb.
22	THSTP(1)	Port thrust, lb.
23	QDEG	Pitch rate, deg/sec.
24	PDEG	Roll rate, deg/sec.
25	RDEG	Yaw rate, deg/sec.
26	DELRS	Rudder angle, degrees.

LISTING OF MAIN PROGRAM AND SUBROUTINES

Main Program

Discussion - The main program contains the logic for interconnecting the various subroutines. In addition, it compares the running value of time with the finish time, calculates the next value of time for printing after each print time, etc. The main program also contains the logic for the fixed coordinate trajectory (x, y, ψ) by the trapazoidal rule.

Output - The output from the main program is controlled by the print option switch ITRAJ. If the value of this switch is 1, the program will print the current values of the time and the craft velocities and displacements (angular and translational).

BLOCK DATA

Discussion - The block data are part of the main program and contain all COMMON-statements used in various subroutine programs. All values therein are initialized with "0.0" before the first data are read into the program. They keep their current values between consecutive runs (controlled by card 013) as far as they are not recalculated due to a change of input values or within the subroutines themselves. Various constants, too, are transferred by COMMON-statements.

Subroutine INCON

Discussion - Subroutine INCON contains the logic for the reading of all input data, the initialization of variables

and for the initiation of new cases. The subroutine is programmed so that the input data is non-structured i.e. there is no set order of input cards from one read statement to another. However, a given read statement may have more than one input card. In runs with multiple cases, only those input parameters which are to be changed for the new case need be read in.

Usage - CALL INCON

Output - The output from INCON is discussed earlier.

Subroutine DMINV

Discussion - Subroutine DMINV is a matrix inversion package used for inverting the mass matrix. The method used is the standard Gauss-Jordan technique. The determinant of the matrix is also calculated. If the determinant is zero the matrix is singular and the program will stop.

Usage - CALL DMINV (A, N, D)

Description of Parameters

A = The input matrix, destroyed in computation and replaced by resultant inverse

N = The order of matrix (maximum = 6)

D = The resultant determinant of the matrix

Subroutine WAVES

Discussion - Subroutine WAVES calculates the wave forces and moments acting on the craft. It also generates the wave heights at the various stations around the seals and sidewalls, as well as the bubble volume lost due to wave elevation. The sea state for irregular seas is computed in

WAVES by adding together a series of regular waves with an appropriate distribution of amplitude and frequency.

Usage - CALL WAVES

Output - The output from WAVES is controlled by print option switch IWAVES. When this switch is set equal to 1, WAVES will print the wave elevation around the seals and sidewalls, the wave elevation at the center of gravity and the volume reduction of the bubble plenum due to waves as well as the total forces and moments acting on the craft due to waves.

Subroutine SIDEWL

Discussion - Subroutine SIDEWL calculates the forces and moments acting on the craft due to the sidewalls as well as the leakage flow rates associated with any gaps which open under the sidewalls due either to craft motion or waves.

Usage - CALL SIDEWL

Output - The output from SIDEWL is controlled by the print option switch ISIDWL. When this switch is equal to 1, the program will print the sidewall gaps, immersion depths and total forces and moments.

Subroutine PROP

Discussion - Subroutine PROP is used to calculate forces and moments on the craft due to the propulsion system. The subroutine has the capability of uneven thrusting and receives this information by using the function program FG1 to linearly interpolate a map input in block 16.

Usage - CALL PROP

Output - The output from PROP is controlled by print option switch IPROP. If this switch is 1, the program will print the calculated forces and moments.

Subroutine RUDDER

Discussion - subroutine RUDDER contains the logic for calculating rudder forces and moments as well as rudder motions. Rudder motions are calculated by employing the function program FG1 to linearly interpolate an optional map input.

Usage - CALL RUDDER

Output - The output from rudder is controlled by print option switch IRUD. If this switch is 1, the program will print out the total forces and moments due to the rudder .

Subroutine AEROD

Discussion -Subroutine AEROD calculates the aerodynamic forces and moments on the craft. The subroutine currently uses curve fits of the aerodynamic coefficients vs sideslip angle.

Usage - Call AEROD

Output - The output from AEROD is controlled by print option switch IAEROD. If this switch is 1, the program will print the total forces and moments.

Subrourine INTGRL

Discussion - Subroutine INTGRL is used to integrate a system of first order ordinary differential equations. It uses a variable time step technique based on the Runge-Kutta-Merson algorithm. A fixed time step Runge-Kutta algorithm is also available. The program will stop the calculation if the time step becomes smaller than 10^{-6}sec.

Usage - CALL INTGRL (TIME)

Description of Parameters

TIME = current value of the independent variable

Subroutine RHS

Discussion - Subroutine RHS is the subprogram containing the FORTRAN expressions for the right hand side of the system of first order differential equations. It contains the logic to calculate the bubble volume, area and pressure as a function of time as well as the logic which sums the individual forces , moments and leakages from the various craft components to get craft totals. RHS also contains the statements used for the writing of the scratch file for the tabular output.

Usage - CALL RHS (VALUE)

Discription of Parameters

VALUE = The array containing the values of the right hand side of the differential equations as calculated in RHS, i.e., for a system of equations of this form $\dot{y}(i) = f(y(i),t)$ the VALUE array is used to store

the values of f(y(i),t).

Output - The output from RHS is controlled by print option switch IRHS. When this switch is 1, the subroutine will print all right hand side forces, moments, accelerations, pressure, air flow rates and fan power besides the complete VAL- and VALUE- arrays. This print switch is the most efficient one for debugging purposes but also computer time consuming.

Subroutine BOWSL

Discussion - Subroutine BOWSL calculates the forces and moments due to the bow seal and the leakage flow rate associated with any gaps which open up under various seal stations.

Usage - CALL BOWSL

Output - The output from BOWSL is controlled by print option switch IBOWSL. If this switch is 1, the program will print the gaps and wetted lengths at the various stations on the bowseal as well as the total forces and moments due to the bowseal.

Subroutine STNSL

Discussion - Subroutine STNSL calculates the forces and moments acting on the craft due to the stern seal as well as the leakage flow rates arising from any gaps which open under the seal.

Usage - CALL STNSL

Output - The output from STNSL is controlled by print option

switch ISTNSL. When this switch is equal to 1, the program will print the seal wetted length, and gaps as a function of station as well as the craft forces and moments due to the stern seal.

Subroutine FAN

Discussion - Subroutine FAN is used to calculate the inflow to the plenum, stern seal, and bowseal from the fans for a given pressure differential across the fans. the subroutine uses tabular data and allows for changes in fan speed as well as the number of fans.

Usage - CALL FAN

Output - The output from FAN is controlled by print option switch IRHS. If this switch is 1, the program will print the flow rates and pressure differentials across the bowseal, cushion and stern seal fans, as well as ideal fan power, actual fan power and fan efficiency.

Subroutine COLFIL

Discussion - Subroutine COLFIL is used to format the program output. It can provide up to 16 variables listed in two tabular summaries of 8 variables each. The subroutine has a plotting package that permits use of either the print plot or calcomp (continuous line) option. Multiple curves may be plotted and up to 10 graphs may be drawn on each run.

Usage -CALL COLFIL

Output - The output from COLFIL is discussed earlier.

Subroutine SAM

Discussion - Subroutine SAM is supposed to calculate the shear and bending moments, but is not used in this program version and replaced by a dummy subroutine.

Function FG1

Discussion - The purpose of FG1 is to perform the task of evaluating a tabular function $y = f(x)$. the procedure used is linear interpolation between data points. If the input value of the independent variable does not fall in the range of its input tabular values the appropriate table extreme is held. The function y must be single valued and the tabular values for the independent variable must be stored in ascending order i.e. XTAB(J)<XTAB(J+1). The increment between tabular values need not be constant.

Usage -Y = FG1 (X,N,XTAB, YTAB, IMEM)

Description of Parameters

Y	=	The output value of the tabular function
X	=	The value of the independent variable to be used to evaluate the function $y = f(x)$
N	=	The number of elements in the XTAB and YTAB arrays
XTAB	=	The name of the array that contains the values of the independent variable in ascending order
YTAB	=	The name of the array that contains the values of the dependent variable corresponding to the values of the independent variable stored in XTAB
IMEM	=	Dummy variable used to store location of last entry into table, to be used as initial point of search at next entry

Function SHXYAX

Discussion - Function SHXYAX calculates the shift of the x-coordinate of a given location due to rotation about the y-axis in the local reference frame. It is used to attain corrected levers the moment calculations.

Usage - XC=SHXYAX(X,Z,ANGYAX,PI)

Description of Parameters

XC	=	Corrected x-coordinate
X	=	Original x-coordinate of given location
Z	=	Original z-coordinate of given location
ANGYAX	=	Angle of rotation about y-axis
PI	=	Constant pi

Functions T1 and T2

Discussion - Functions T1 and T2 are two small FUNCTION-subprograms used to calculate various trignometric relations used by subroutine WAVES.

LISTING OF BLOCKS

The names mentioned in the following summary are used in subroutine INCON. Not all of them are transferred as read to other subprograms. An investigation of the corresponding COMMON-statement may give further hints, but care must be taken as those names may be not identical in all subroutines.

Block 1 Executive Input

Option tag 1 = Time steps

Card	Column	Format	Name	Entry
1	1-5	I		00101
	6-15	F10	STIME	Start time (generelly zero), sec.
	16-25	F10	FTIME	Finish time, sec.
	26-35	F10	DELO	Initial integration time step, sec.
	36-45	F10	DELPNT	Print interval, sec.
	46-55	F10	TPRINO	Print start time, sec.

Option tag 2 = Print switches

Card	Column	Format	Name	Entry
1	1-5	I		00102
2	5	I	IACCEL	Print switch for lateral acceleration and integration time step.
	10	I	IVEL	Not used at present.
	15	I	ITRAJ	Print switch for main program.

Card	Column	Format	Name	Entry (cont)
2	20	I	ISIDWL	Print switch for subroutine SIDEWL.
	25	I	IBOWSL	Print switch for subroutine BOWSL.
	30	I	ISTNSL	Print switch for subroutine STNSL.
	35	I	IWAVES	Print switch for subroutine WAVES.
	40	I	IRUD	Print switch for subroutine RUDDER.
	45	I	IPROP	Print switch for subroutine PROP.
	50	I	IAEROD	Print switch for subroutine AEROD.
	55	I	IRHS	Print switch for subroutine RHS and FAN.

Option tag 3 = Integrator tolerances

Card	Column	Format	Name	Entry
1	1-5	I		00103
2	1-2	I2	NEQS	Number of integrators to be used (maximum of 15).
	3-4	I2	JQQ	Control tag for integration procedure. 00 = original Runge-Kutta procedure. 01 = fixed step size Runge-Kutta procedure. 02 = variable step size Runge-Kutta procedure. Only the minimum step size is output.

Card	Column	Format	Name	Entry (cont)
3,4,.	1-80	8F10	TOL(J)	Integrator error tolerance, one per integrator.

Note:

The usual procedure for selecting integrator tolerances is to choose values on the order of 10-5 to 10-8. For a new craft the following procedure is used:

Make a run with a given set of tolerances; halve the tolerances and rerun. If the results do not change drastically, try doubling the original tolerances and rerun. As changes are noted in the integrator outputs (i.e. craft velocities, etc.), hold the tolerances for those integrators fixed and vary the others until the largest tolerances possible are obtained. Once chosen for a given craft the tolerances rarely have to be changed.

Option tag 4 = Tabular summary of output

Card	Column	Format	Name	Entry
1	1-5	I		00104
2	5	I	IVERT	Print switch for summary one 1 = print, 0 = no print.
	10	I	ILATRL	Print switch for summary two 1 = print, 0 = no print.
	15	I	NVD	Not used at present.
	20	I	NVI	Not used at present.
	25	I	NLD	Not used at present.
	30	I	NLI	Not used at present.

Option tag 5 = Program option switches

Card	Column	Format	Name	Entry
1	1-5	I		00105

Card	Column	Format	Name	Entry (cont)
1	6-15	F10	I3DOF	Switch for lateral plane motions. 1 = only lateral plane motions 0 = six degrees of freedom.
	16-25	F10	ISRGE	Switch for constant speed. 1 = surge equation not used. 0 = surge velocity allowed to vary.
	26-35	F10	ITRIM	Switch for trim. 1 = thrust varied to give proper speed. If this option is selected, then there must be input in Block 16 an estimate of thrust and a 0.0 for the number of data points. 0 = thrust as input.
	36-45	F10	IDIA	Switch for membrane study concerning plenum air bubble.

Option tag 6 = Program modification settings

Card	Column	Format	Name	Entry
1	1-5	I		00106
	6-15	F10	PROMO1	Program modification setting 1 (temporarily used as deadrise factor).
	16-25	F10	PROMO2	Program modification setting 2 (temporarily used as roll damping factor).
	26-35	F10	PROMO3	Program modification setting 3 (temporarily used as print switch for vertical forces and roll moments in subroutine SIDEWL).

Card	Column	Format	Name	Entry (cont)
1	36-45	F10	PROMO4	Program modification setting 4
	46-55	F10	PROMO5	Program modification setting 5
	56-65	F10	PROMO6	Program modification setting 6
	66-75	F10	PROMO7	Program modification setting 7

Block 2 Mass and inertial Input

Option tag 1 =1 Summary mass properties card

Note: In this option shears and moments will not be calculated correctly.

Card	Column	Format	Name	Entry
1	1-5	I		00201
	6-15	F10	WEIGHT	Total craft weight, pounds.
	16-25	F10	XS	Longitudinal center of gravity, feet forward of transom.
	26-35	F10	ZS	Vertical center of gravity, feet above baseline (keel).
	36-45	F10	AIXX	Mass moment of inertia about x axis, slug-sq ft.
	46-55	F10	AIYY	Mass moment of inertia about y axis, slug-sq ft.
	56-65	F10	AIZZ	Mass moment of inertia about z axis, slug-sq ft.
	66-75	F10	AIXZ	Mass moment of inertia about xz axis, slug-sq ft.

Option tag 2 = Discrete mass distribution cards

Card	Column	Format	Name	Entry
1	1-5	I		00202
2,3,..	1-10	F10	AMI(I)	Discrete weight, pounds.

Card	Column	Format	Name	Entry (cont)
2,3,.	11-20	F10	XI(I)	Longitudinal center of gravity, feet forward of transom.
	21-30	F10	YI(I)	Transverse center of gravity, feet to starboard.
	31-40	F10	ZI(I)	Vertical center of gravity, feet above baseline (keel).
Last card	1-10	F10		Discrete weights termination tag. (must be less than 0.0)

Note:

The maximum number of discrete weights is 201. They are assumed in symmetric distribution about the longitudinal center plane, so that only weights on starboard side should be specified, with atransverse location greater than zero.

Block 3 Craft Geometric Input

No options

Card	Column	Format	Name	Entry
1	1-5	I		00301
	6-15	F10	NSTA(1)	Number of stations on port sidewall.
	16-25	F10	NSTA(2)	Number of stations on starboard sidewall.
	26-35	F10	NSTA(3)	Number of stations on bow seal.
	36-45	F10	NSTA(4)	Number of stations on stern seal.
	46-55	F10	XLTOT	Total craft length.

Note:

The maximum number of stations is 11 for each element. The program will automatically subdivide the element into N-1 sections (N is the number of stations) and calculate the x and y coordinates of each station.

Block 4 Sidewall Input

Option tag 1 = Sidewall input

Card	Column	Format	Name	Entry
1	1-5	I		00401
	6-15	F10	YSW	y distance from centerline to sidewall, feet.
	16-25	F10	XLSW	Average wetted length of sidewall, feet.
	26-35	F10	CFSW	Leakage orfice coefficient of sidewall.
	36-45	F10	CDSW	Cross-flow drag coefficient of sidewall.
	46-55	F10	AVBMSW	Average beam of sidewall, feet.

Note:

Under this option tag the program will also read the sidewall integral table file stored on a special unit for fast access.

Block 5 Stern Seal Input

No cptions

Card	Column	Format	Name	Entry
1	1-5	I		00501

Card	Column	Format	Name	Entry (cont)
1	6-15	F10	XSSI	x coordinate of seal hinge, feet forward of tramsom.
	16-25	F10	ZSSI	z coordinate of seal hinge, feet above keel.
	26-35	F10	ALEAK	Base leakage area, sq ft. (3.79 sq ft is nominal.)
	36-45	F10	CFSS	Seal leakage orifice coefficient.
	46-55	F10	ELMAXS	Length of rear support cable, feet. (1.875 feet is full down.)
	56-65	F10	DPBS	Pressure differential between stern seal and plenum chamber, psf.
	66-75	F10	XLF	Length of leading edge of the seal, feet.

Block 6 Bowseal Input

Option tag 1 = First data card

Card	Column	Format	Name	Entry
1	1-5	I		00601
	6-15	F10	XBSI	x coordinate of seal hinge, feet foreard of transom.
	16-25	F10	CFBS	Seal leakage orifice coefficient.
	26-35	F10	DPBS	Pressure differential between bow seal and plenum chamber, psf.
	36-45	F10	ZBSI	z coordinate of seal hinge, feet above keel.

Card	Column	Format	Name	Entry (cont)
1	46-55	F10	ELMAXB	Length of rear support cable, feet. (1.875 feet is full down.)
	56-65	F10	XBF	Length of seal leading edge, feet.
	66-75	F10	BLEAK	Base leakage area, sq ft.

Option tag 2 = Second data card

Card	Column	Format	Name	Entry
1	1-5	I		00602
	6-15	F10	CENCAB	Length of middle support cable, feet. (1.875 feet is full down.)

Block 7 Plenum Input

Option tag 1 = Plenum geometry

Card	Column	Format	Name	Entry
1	1-5	I		00701
	6-15	F10	XLBW	Plenum length at water surface, feet.
	16-25	F10	XBBW	Plenum width at water surface, feet.
	26-35	F10	XPWV	x coordinate of pressure wave pivot point, feet forward of transom.
	36-45	F10	WIDTH	Plenum width at deck, feet.
	46-55	F10	XL	Plenum length at deck, feet.
	56-65	F10	XCPO	x coordinate of center of pressure, feet forward of transom.

Card	Column	Format	Name	Entry (cont)
1	66-75	F10	BUBHGT	Plenum average height, feet.

Option tag 2 = Critical Froude number

Card	Column	Format	Name	Entry
1	1-5	I		00702
	6-15	F10	FNCRIT	Froude number corresponding to hump speed.

Block 8 Propulsion Input

No options

Card	Column	Format	Name	Entry
1	1-5	I		00801
	6-15	F10	XPO	x coordinate of propeller center, feet forward of transom.
	16-25	F10	YPO	y distance from centerline to propeller center, feet.
	26-35	F10	ZPO	z coordinate of propeller, feet above keel.

Block 9 Rudder Input

No options

Card	Column	Format	Name	Entry
1	1-5	I		00901
	6-15	F10	XRO	x coordinate of centroid of rudder, feet forward of transom.

Card	Column	Format	Name	Entry (cont)
1	16-25	F10	YR	y distance from centerline to rudder centroid, feet.
	26-35	F10	ZRO	z coordinate of centroid of rudder, feet above keel.
	36-45	F10	RSPAN	Rudder span, feet.
	46-55	F10	RASPR	Rudder aspect ratio.
	56-65	F10	RAREA	Rudder area, sq ft.
	66-75	F10	RTC	Average thickness ratio of rudder section.

Block 10 Aerodynamic Input

No options

Card	Column	Format	Name	Entry
1	1-5	I		01001
	6-15	F10	XLAERO	Reference length, feet.
	16-25	F10	BEAM	Reference width, feet.

Note:

The reference length and width are those used to nondimensionalize the wind tunnel data used in the program.

Block 11 Sea State Input

Option tag 1 = Amplitude versus frequency

Card	Column	Format	Name	Entry
1	1-5	I		01101
	6-15	F10	NWAVE	Number of wave components, maximum of 10.
	16-25	F10	BETAD	Initial wave heading, degrees. (180 degrees = ahead waves)

Card	Column	Format	Name	Entry (cont)
2,3,.	1-10	F10	OMEGA(I)	Wave frequency, rad/sec.
	11-20	F10	AW(I)	Wave amplitude, feet.

Option tag 2 = Amplitude versus wave length

Card	Column	Format	Name	Entry
1	1-5	I		01102
	6-15	F10	NWAVE	Number of wave components, maximum of 10.
	16-25	F10	BETAD	Initial wave heading, degrees. (180 degrees = ahead waves)
2,3,.	1-10	F10	WAVLEN(I)	Wave length, feet.
	11-20	F10	AW(I)	Wave amplitude, feet.

Note:
In this options irregular seas are constructed by addition of regular wave components. For a regular sea case only one component is input. If the number of components is zero (calm water), only the first card may appear.

Option tag 3 = Wave components by calculation for given period limits

Card	Column	Format	Name	Entry
1	1-5	I		01103
	6-15	F10	NWAVE	Number of wave components, maximum of 10.
	16-25	F10	BETAD	Initial wave heading, degrees. (180 degrees = ahead waves)
	26-35	F10	SHTWV	Average height of1/3 highest waves, feet.
	36-45	F10	PERL	Shortest significant period of waves, seconds.

Card	Column	Format	Name	Entry (cont)
1	46-55	F10	PERH	Longest significant period of waves, seconds.

Option tag 4 = Wave components by calculation for given frequency limits

Card	Column	Format	Name	Entry
1	1-5	I		01104
	6-15	F10	NWAVE	Number of wave components, maximum of 10.
	16-25	F10	BETAD	Initial wave heading, degrees. (180 degrees = ahead waves)
	26-35	F10	SHTWV	Average height of1/3 highest waves, feet.
	36-45	F10	WWN	Lowest significant frequency of waves, Hertz.
	46-55	F10	WWX	Highest significant frequency of waves, Hertz.

Note:
In options 3 and 4 the wave components are calculated in order to ease the input requirements for irregular sea cases.

Block 12 Initial Conditions

No options

Card	Column	Format	Name	Entry
1	1-5	I		01201
	6-15	F10	UO	Initial speed, knots.
	16-25	F10	THETO	Initial pitch angle (positive - nose up, in degrees).

Card	Column	Format	Name	Entry (cont)
1	26-35	F10	DSO	Initial draft at center of gravity, inches.
	36-45	F10	DELPI	Initial bubble gage pressure, psf.

Block 13 End of Case

No options

Card	Column	Format	Name	Entry
1	1-5	I		013

Note:
This card signals the end of data for a given case. Two consecutive 013 cards with no data between will stop the job unduly.

Block 14 End of Run

No options

Card	Column	Format	Name	Entry
1	1-5	I		014

Note:
This card signals the end of the run. this will be indicated by the message: COMPLETED ALL RUNS.

Block 16 Thrust and Rudder Input

Option tag 1 = Starboard thrust input

Card	Column	Format	Name	Entry
1	1-5	I		01601

Card	Column	Format	Name	Entry (cont)
1	6-15	F10	THST1	Value of the thrust for the starboard screw. This is an estimate or kept fixed depending on option switch in Block 00105.
	16-25	F10	NPS	Number of data points in the thrust map. Left blank if no thrust map is used.
	26-35	F10	STHS	Side thrust coefficient.
2,3,.	1-80	8F10	TIS(J)	Data points for independent variable time in ascending order.
	1-80	8F10	THSTS(J)	Corresponding data points for the dependent variable.

Note: NPS must not be larger than 25.

Option tag 2 = Port thrust input

Card	Column	Format	Name	Entry
1	1-5	I		01602
	6-15	F10	THST2	As above for port screw.
	16-25	F10	NPP	As above for port screw.
	26-35	F10	STHP	As above for port screw.
2,3,.	1-80	8F10	TIP(J)	As above for port screw.
	1-80	8F10	THSTP(J)	As above for port screw.

Note: NPP must not be larger than 25.

Option tag 3 = Rudder motion input

Card	Column	Format	Name	Entry
1	1-5	I		01603

Card	Column	Format	Name	Entry (cont)
1	6-15	F10	DELR	Value of rudder if constant rudder is desired (in degrees).
	16-25	F10	NPR	Number of data points of the rudder map. Left blank if constant rudder is desired.
2,3,.	1-80	8F10	TIR(J)	Values of independent variable time in ascending order.
	1-80	8F10	DELRUD(J)	Corresponding values of rudder angle (in degrees). Note: Positive rudder angle is rignt rudder.

Note: NPR must not be larger than 25.

Block 17 Bow and Stern Seal Pressure Differences Input

Option tag 1 = Bow seal

Card	Column	Format	Name	Entry
1	1-5	I		01701
	6-15	F10	NB	Number of data points for the bow seal.
2,3,.	1-80	8F10	TMEB(I)	Time points in ascending order.
6,7,.	1-80	8F10	DELB(I)	Corresponding differences in bow seal pressures.

Option tag 2 = Stern seal

Card	Column	Format	Name	Entry
1	1-5	I		01702

Card	Column	Format	Name	Entry (cont)
1	6-15	F10	NS	Number of data points for the stern seal.
2,3,.	1-80	8F10	TMES(I)	As for option 1, for stern seal.
6,7,.	1-80	8F10	DETS(I)	As for option 1, for the stern seal.

Note:
If constant pressures are desired, those values shall be input in block 5 and/or block 6. This block can be used for one seal alone, too.

Block 18 Title Card

No options

Card	Column	Format	Name	Entry
1	1-5	I		01801
2	1-80	20A4	TITLC	Alphanumeric data to be printed as title in input summary.

Block 19 Fan Maps

Option tag 1 = Bow seal fans

Card	Column	Format	Name	Entry
1	1-5	I		01901
	6-15	F10	ENBFAN	Number of bow seal fans.
	16-25	F10	BRPM	Speed of bow seal fans, rpm.
	26-35	F10	NPTSB	Number of data points. (maximum of 25)

Card	Column	Format	Name	Entry (cont)
1	36-45	F10	READIN	If this is a 1.0 then the following data points are read. If left blank no further read takes place.
2,3,.	1-80	8F10	PBFAN(J)	Tabular values of fan pressure differential, psf.
6,7,.	1-80	8F10	QBFAN(J)	Corresponding volumetric flow rate, cb ft/sec.

Option tag 2 = Cushion fans

Card	Column	Format	Name	Entry
1	1-5	I		01902
	6-15	F10	ENMFAN	Number of cushion fans.
	16-25	F10	EMRPM	Speed of cushion fans, rpm.
	26-35	F10	NPTSM	Number of data points. (maximum of 25)
	36-45	F10	READIN	If this is a 1.0 then the following data points are read. If left blank no further read takes place.
2,3,.	1-80	8F10	PMFAN(J)	Tabular values of fan pressure differential, psf.
6,7,.	1-80	8F10	QMFAN(J)	Corresponding volumetric flow rate, cb ft/sec.

Option tag 3 = Stern seal fans

Card	Column	Format	Name	Entry
1	1-5	I		01903
	6-15	F10	ENSFAN	Number of stern seal fans.
	16-25	F10	SRPM	Speed of stern seal fans, rpm.

Card	Column	Format	Name	Entry (cont)
1	26-35	F10	NPTSS	Number of data points. (maximum of 25)
	36-45	F10	READIN	If this is a 1.0 then the following data points are read. If left blank no further read takes place.
2,3,.	1-80	8F10	PSFAN(J)	Tabular values of fan pressure differential, psf.
6,7,.	1-80	8F10	QSFAN(J)	Corresponding volumetric flow rate, cb ft/sec.

Note:

The tabular pressure data for all the fans must be stored in order of increasing pressure. The data is for a single fan.

Block 20 Required Curves on Graph

No options

Card	Column	Format	Name	Entry
1	1-3			020
2	1-10	10I1	NCURV	The number of this curve on the corresponding graph, i.e. column 1 pertains to graph 1, column 2 to graph 2, e.t.c. 0 = only one curve per graph. 1 = first of more than one curves per graph. 2 = intermediate of three curves per graph. 3 = last of more than one curves per graph.

Note: Maximum number of curves per graph = 3.
Maximum number of graphs = 10.

Block 21 Tabular Summaries

No options

Card	Column	Format	Name	Entry
1	1-3	I3		021
2	1-16	8I2	ISUM1	Numbers corresponding to the variable names to be printed out in summary one.
3	1-16	8I2	ISUM2	Number corresponding to the variable names to be printed out in summary two. Summary two is printed out in successive runs without the cards being repeated.

Block 22 Required Graphs

No options

Card	Column	Format	Name	Entry
1	1-3	I3		022
2	1-2	I2	NGRAF	Number of graphs desired, right justified, up to and including 10.
	3-4	I2	NDRW	00 = print plot 01 = CALCOMP plot
3	1-52	26I2	NXYS	Numbers corresponding to the variable names desired for the X and Y axes of the graphs in alternating manner.

Card	Column	Format	Name	Entry (cont)
4	1-48	6A8	TICRD	Alpha-numerical title on the first line of the CALCOMP plot. Blank if print plot is desired.

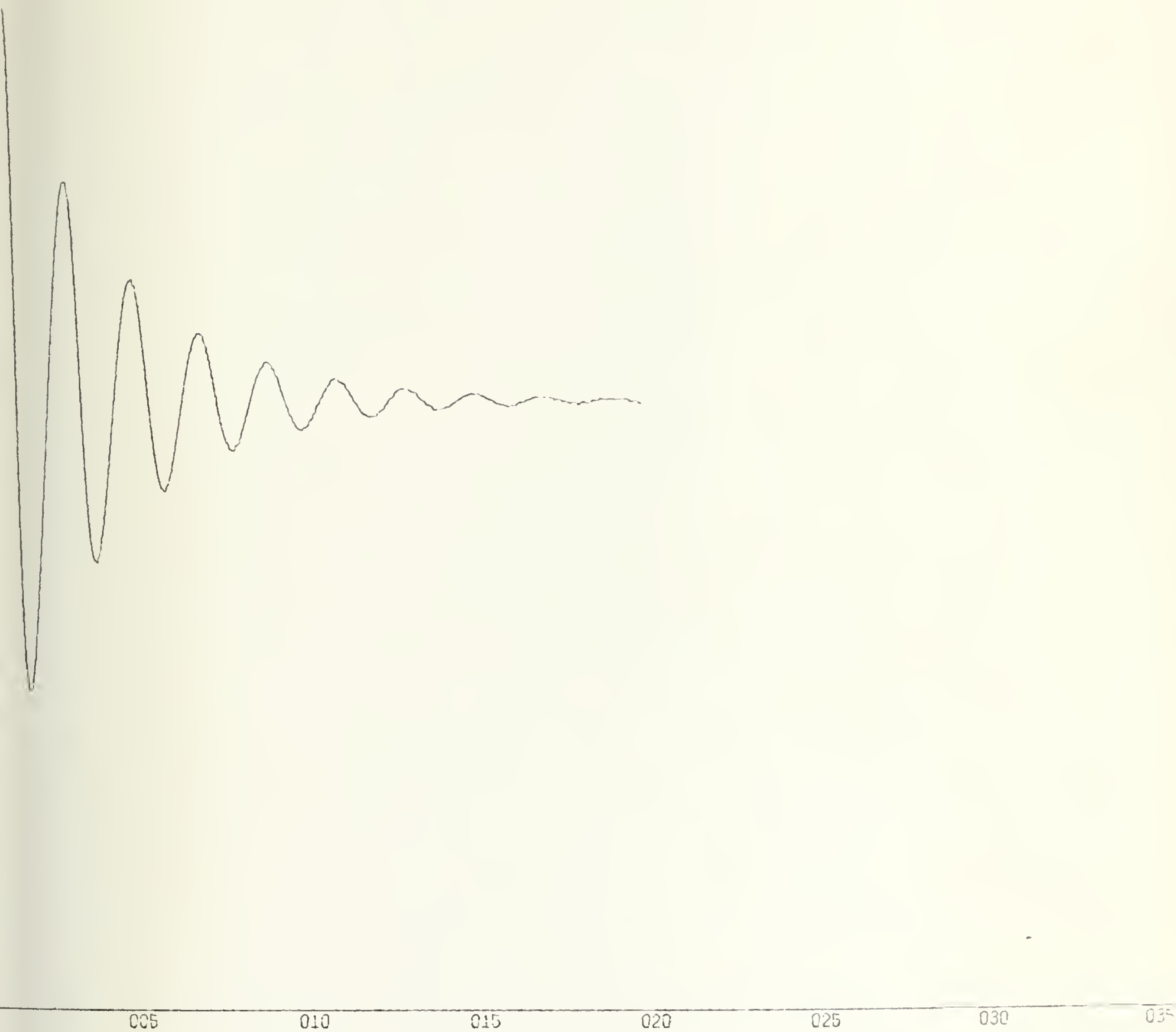
Final Note

In order to maintain the pitch angle curve of figure 9 the present computer model has a speed dependent shift routine of XCPO of the following form:

XCPU=XCP+A*(U*0.5921-30.0)**2+B

After program modifications the coefficients A and B may be re-calculated by setting XCPU equal to XCP and using different input values for XCPO at 10 knots and 30 knots until the desired pitch angles are obtained. Figure 8 gives some initial estimates. From the two data points the values for A and B can be determined replacing XCPO by its original value again.

PLOT 1



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-SCALE=5.00E-01 UNITS INCH.
ROGRAM 2, 1. STRAIGHT RUN AT 20 KNOTS
LOT IS PITCH ANGLE VERSUS TIME

PLOT 2

SCALE=5.00E+00 UNITS INCH.

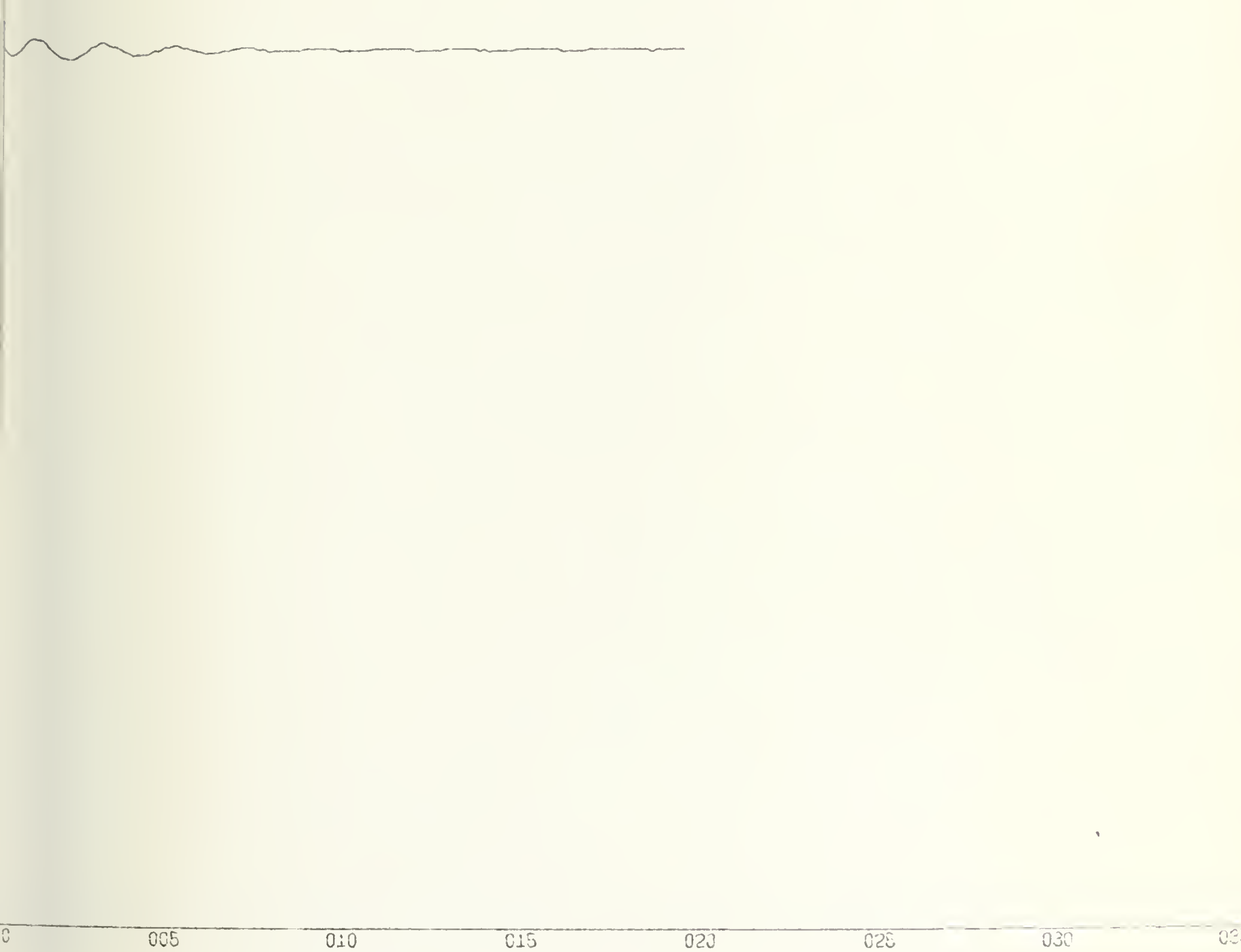
SCALE=1.00E+00 UNITS INCH.

ROGRAM 2, 1. STRAIGHT RUN AT 20 KNØTS

LØT IS Z DISPLACEMENT VERSUS TIME

104

PLOT 3



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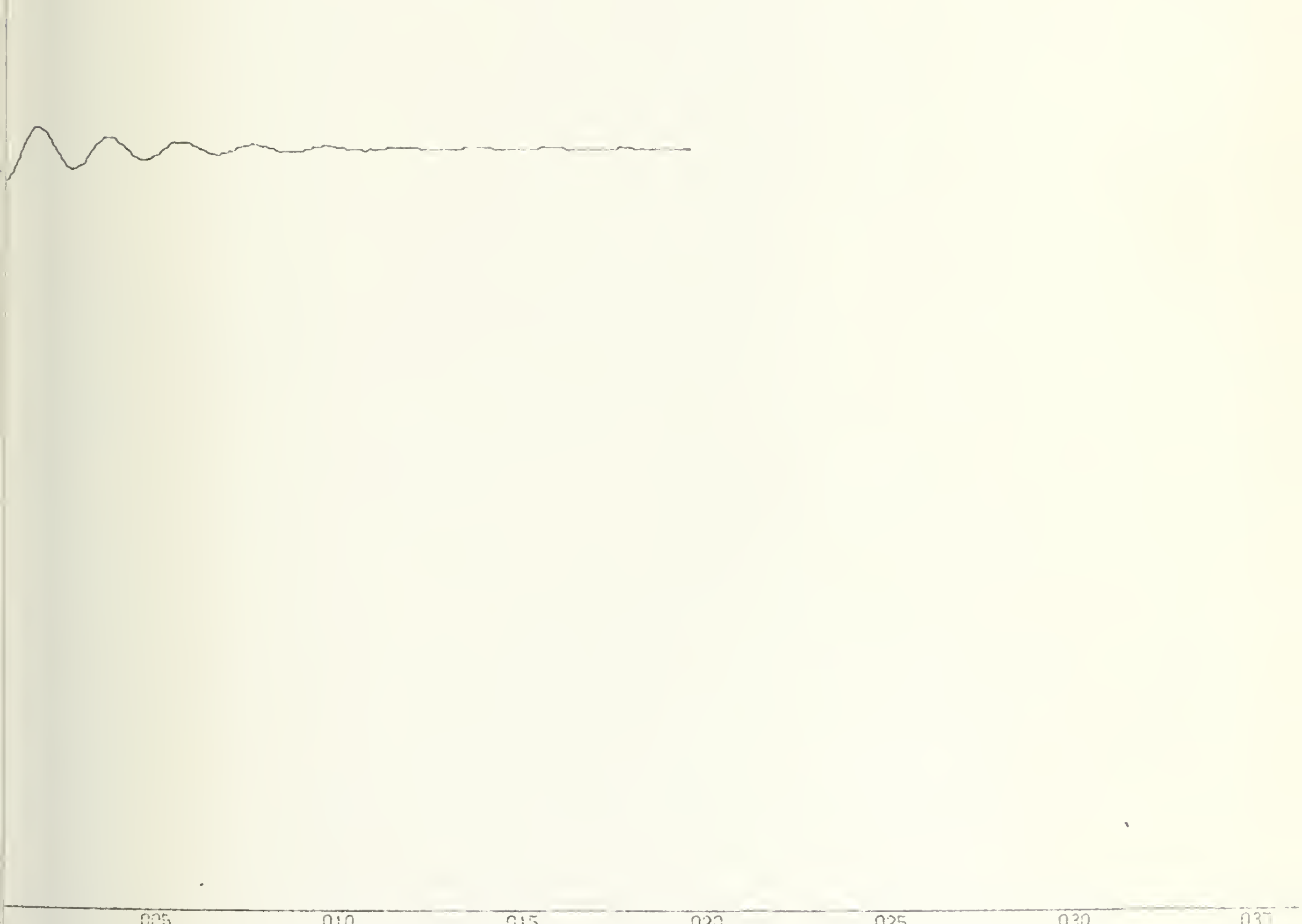
PRØGRAM 2, 1. STRAIGHT RUN AT 20 KNØTS
PLØT IS PLENUM PRESSURE VERSUS TIME

PLOT 4



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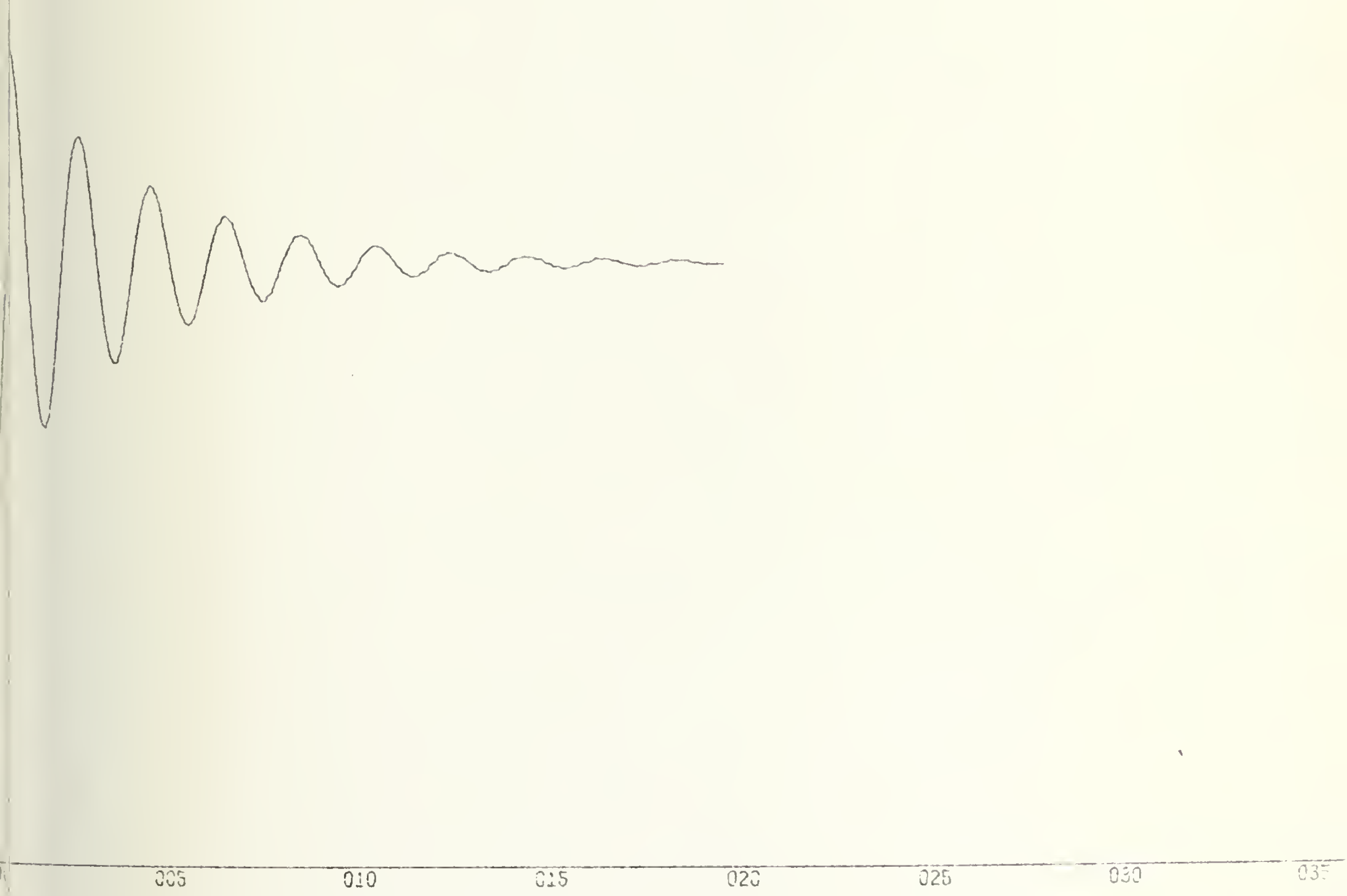
SCALE=5.00E+01 UNITS INCH.
RØGRAM 2, 1. STRAIGHT RUN AT 20 KNØTS
LØT IS THRUST STARBØARD VERSUS TIME

PLOT 5



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-SCALE=2.00E-01 UNITS INCH.

ROGRAM 2, 2. STRAIGHT RUN AT 20 KNOTS

LOT IS PITCH ANGLE VERSUS TIME

PLOT 6

SCALE=5.00E+00 UNITS INCH.

SCALE=1.00E+00 UNITS INCH.

ROGRAM 2, 2. STRAIGHT RUN AT 20 KNØTS

LØT IS Z DISPLACEMENT VERSUS TIME

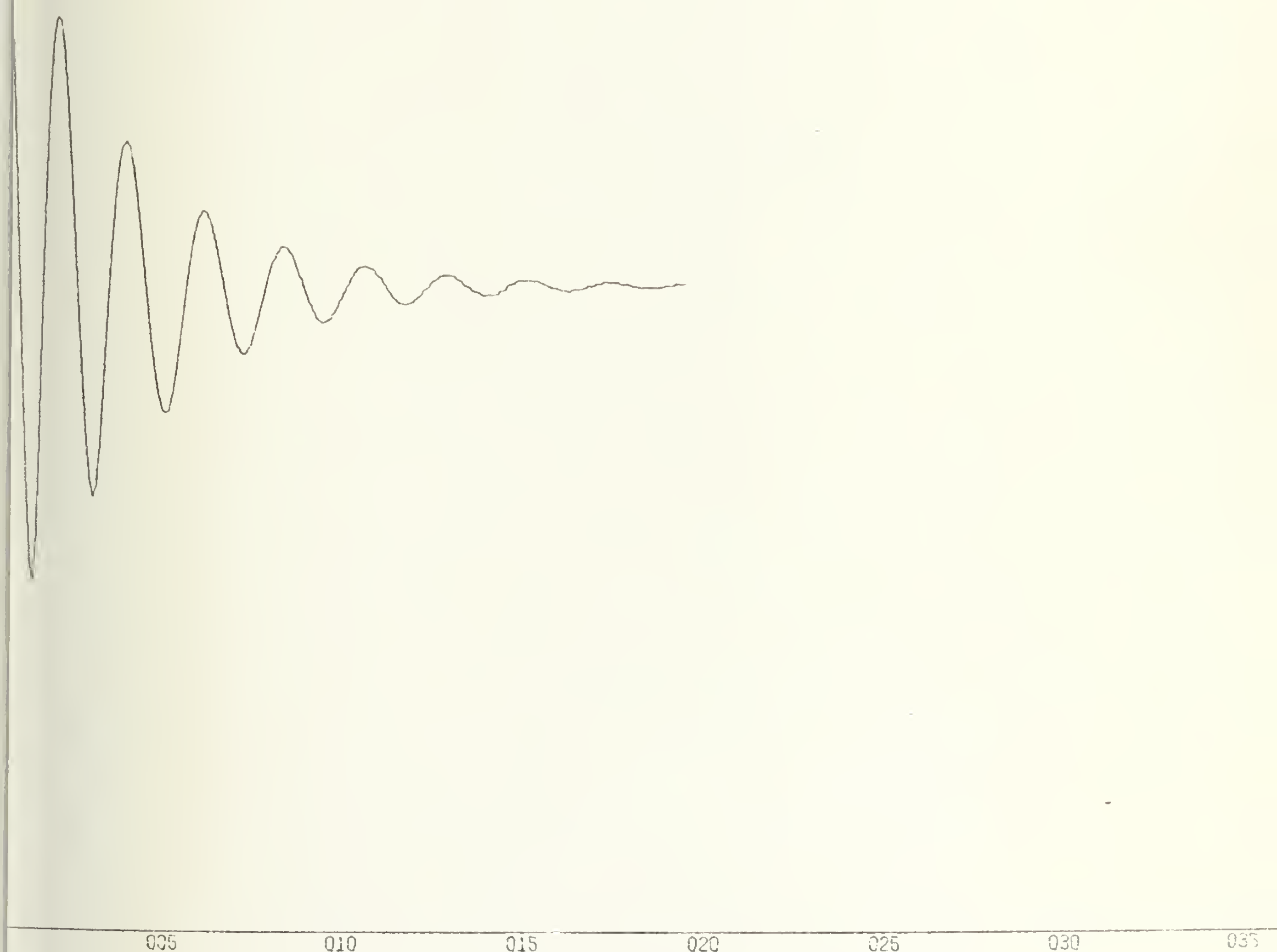
PLOT 7

-SCALE=5.00E+00 UNITS INCH.
-SCALE=5.00E+00 UNITS INCH.
PROGRAM 2, 2. STRAIGHT RUN AT 20 KNOTS
PLOT IS PLENUM PRESSURE VERSUS TIME

PLOT 8

-SCALE=5.00E+00 UNITS INCH.
-SCALE=5.00E+01 UNITS INCH.
ROGRAM 2, 2. STRAIGHT RUN AT 20 KNOTS
LOT IS THRUST STARBOARD VERSUS TIME

PLOT 9



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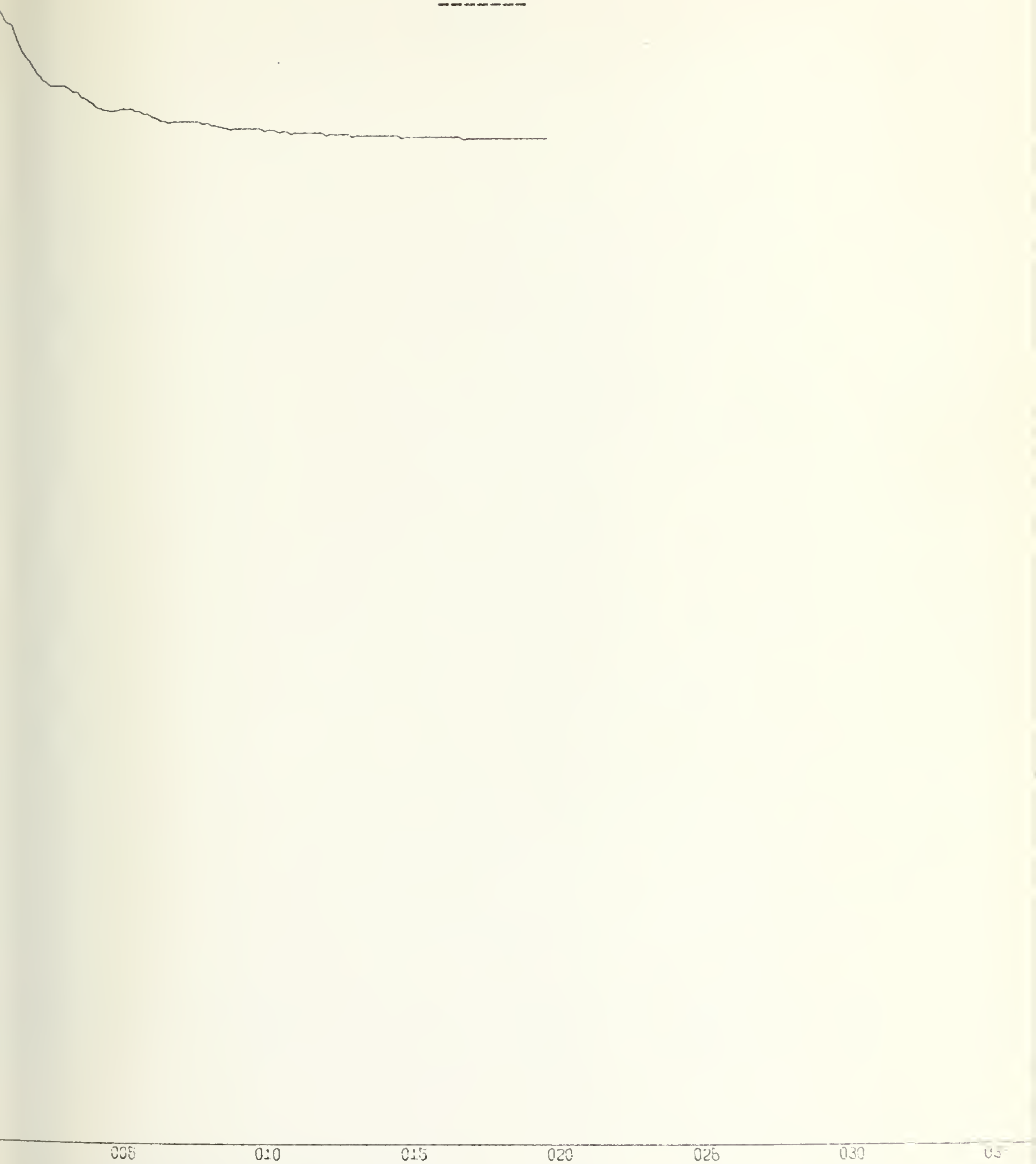
RØGRAM 3. 1. STRAIGHT RUN AT 20 KNØTS
LØT IS PITCH ANGLE VERSUS TIME

PLOT 10



-SCALE=5.00E+00 UNITS INCH. 112

-SCALE=1.00E+00 UNITS INCH.

ROGRAM 3, 1. STRAIGHT RUN AT 20 KNOTS

LOT IS Z DISPLACEMENT VERSUS TIME

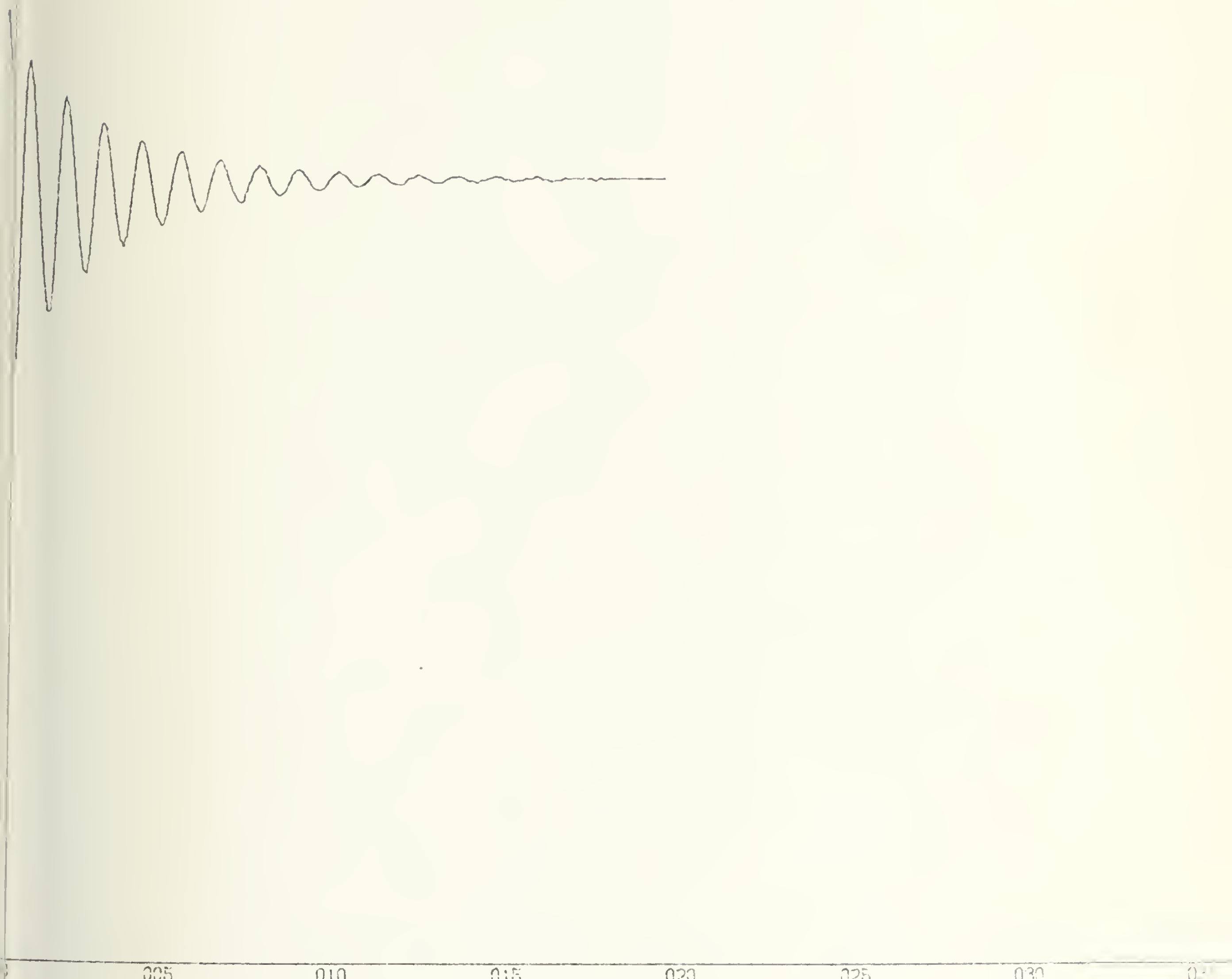
PLOT 11

-SCALE=5.00E+00 UNITS INCH.
-SCALE=5.00E+00 UNITS INCH.
ROGRAM 3, 1: STRAIGHT RUN AT 20 KNOTS
LOT IS PLENUM PRESSURE VERSUS TIME

PLOT 12

SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+01 UNITS INCH.
RØGRAM 3, 1. STRAIGHT RUN AT 20 KNØTS
LØT IS THRUST STARBØARD VERSUS TIME

PLOT 13



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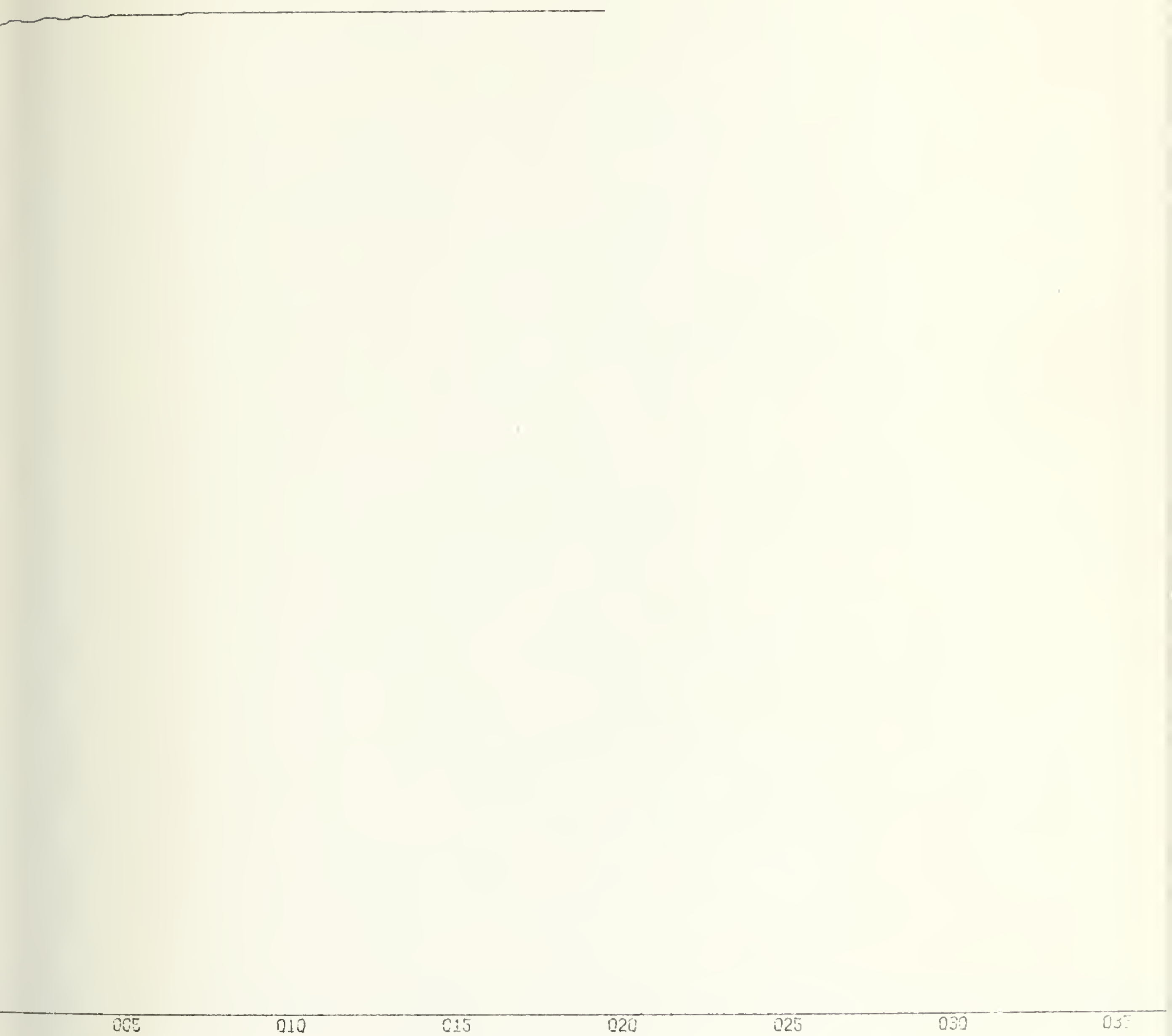
ROGRAM 3, 2. STRAIGHT RUN AT 20 KNOTS
LOT IS PITCH ANGLE VERSUS TIME

PLOT 14



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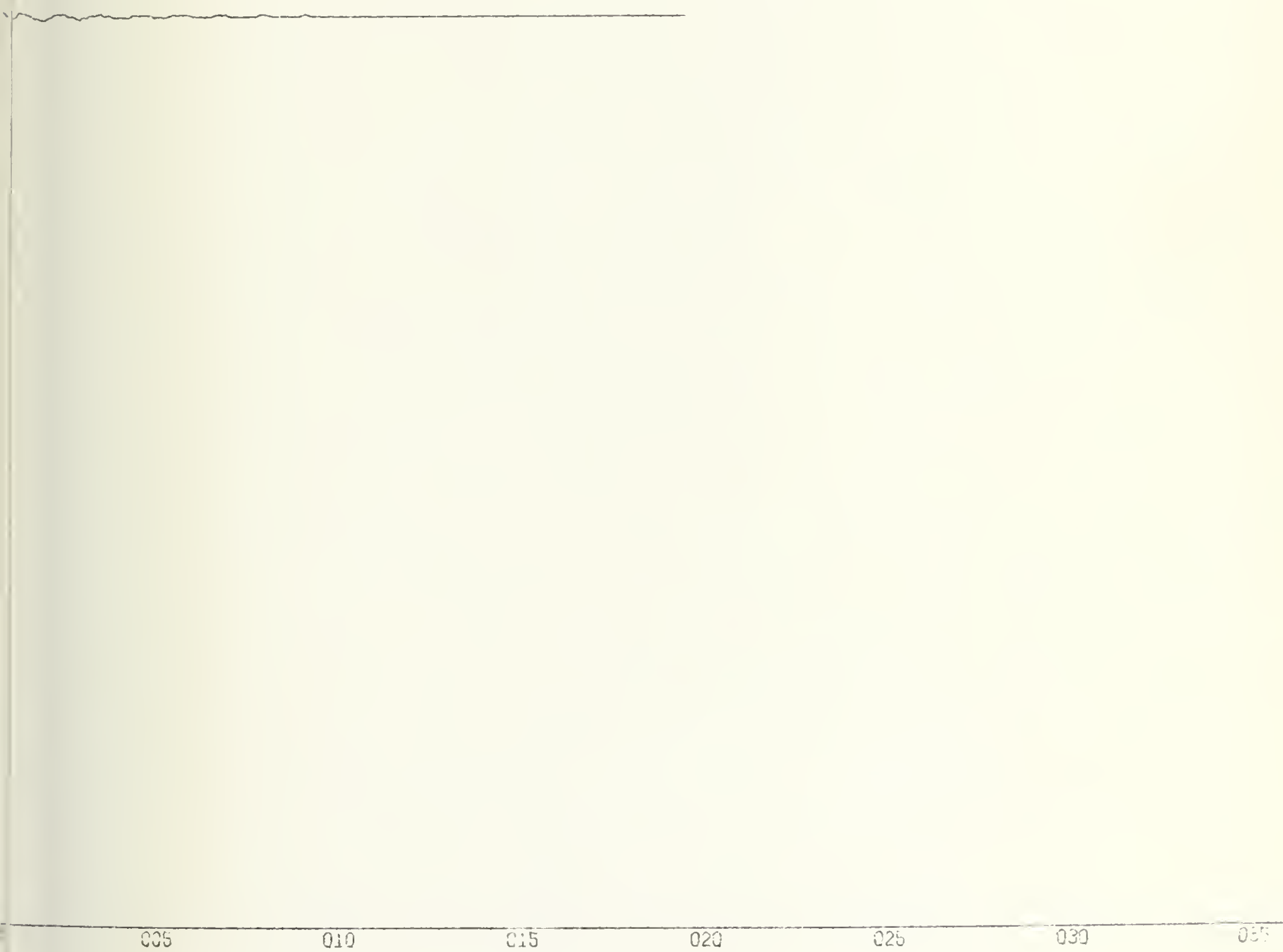
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, 2. STRAIGHT RUN AT 20 KNØTS
OT IS Z DISPLACEMENT VERSUS TIME

PLOT 15



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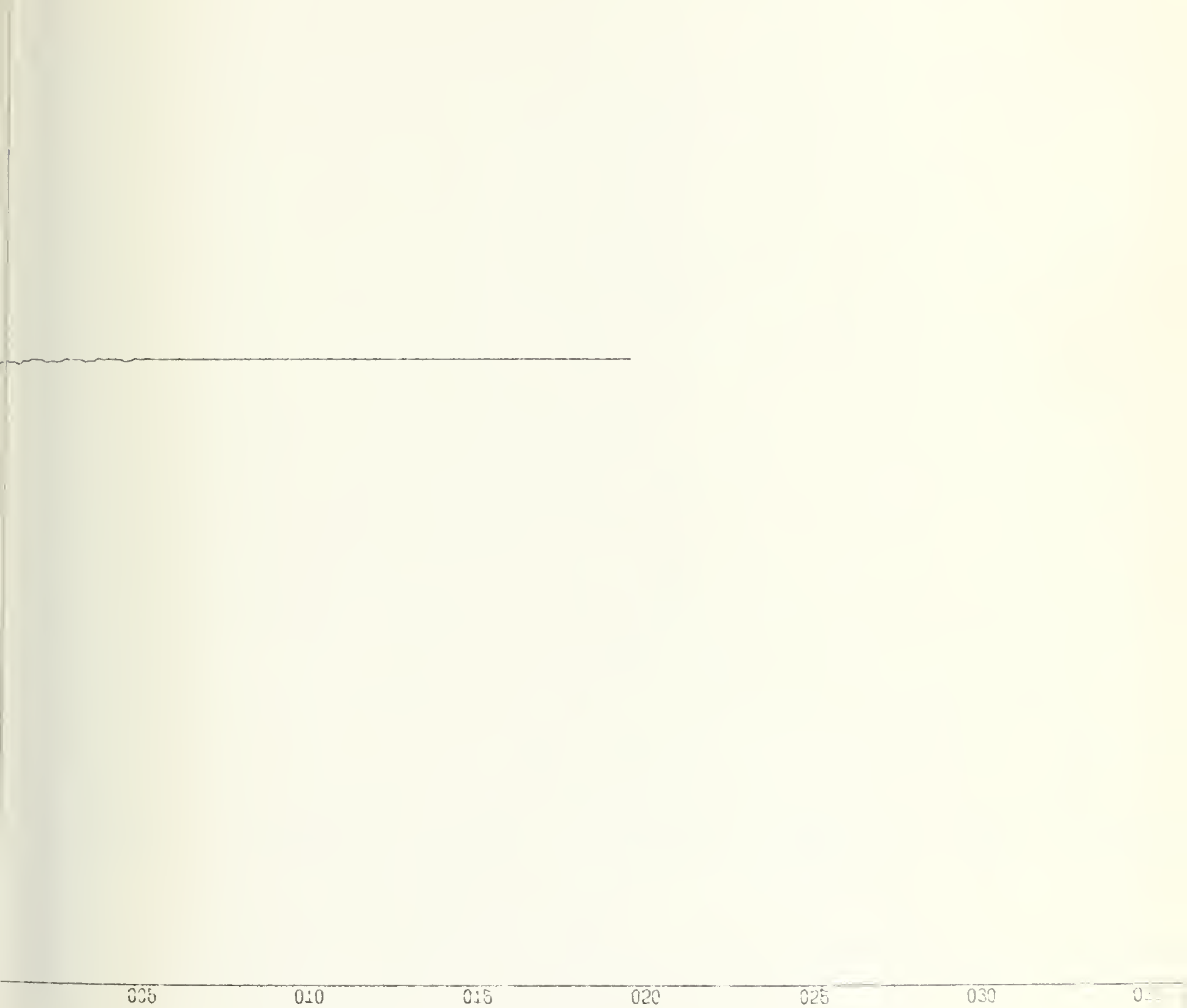
ROGRAM 3. 2. STRAIGHT RUN AT 20 KNOTS
LOT IS PLENUM PRESSURE VERSUS TIME

PLOT 16



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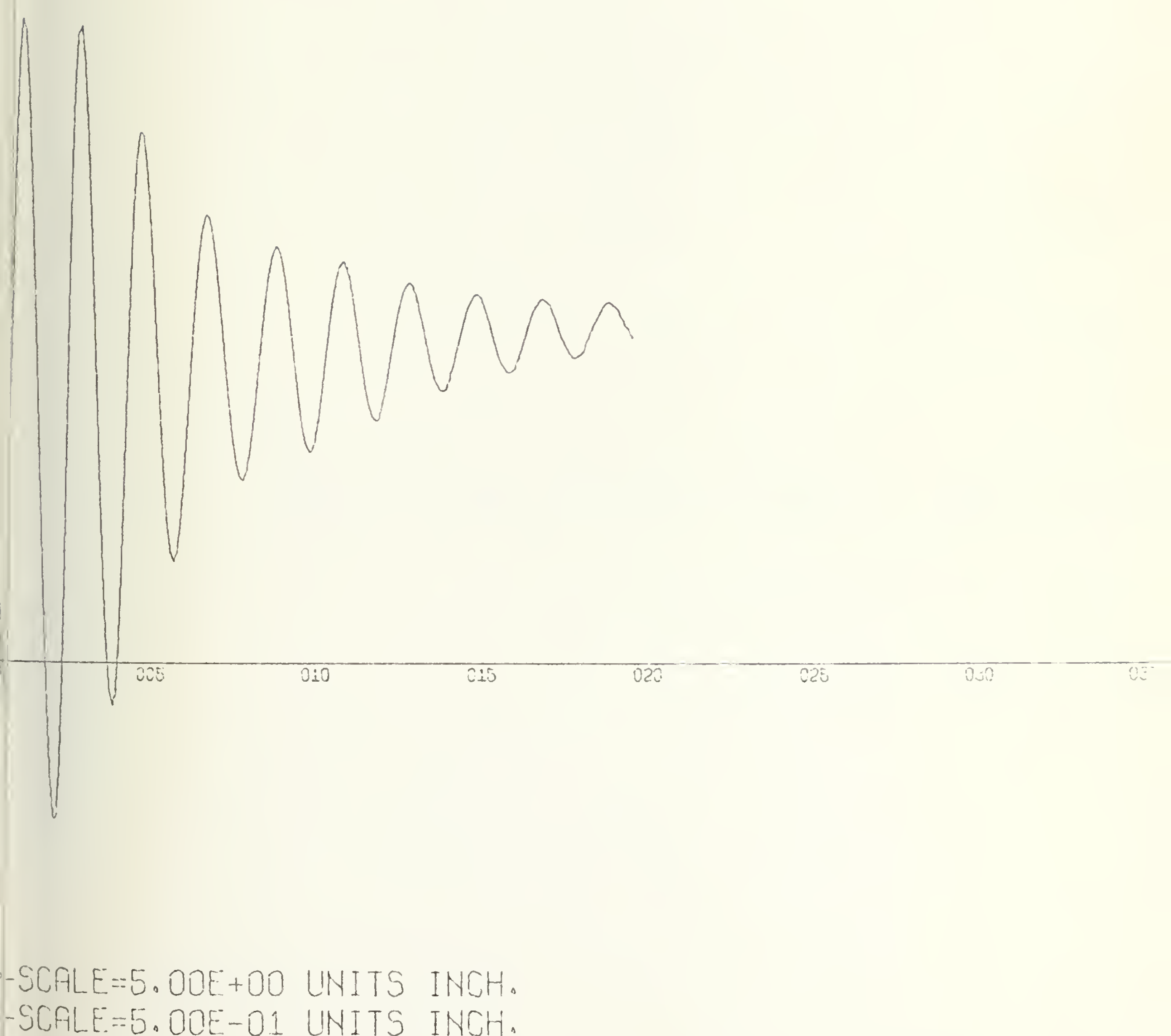
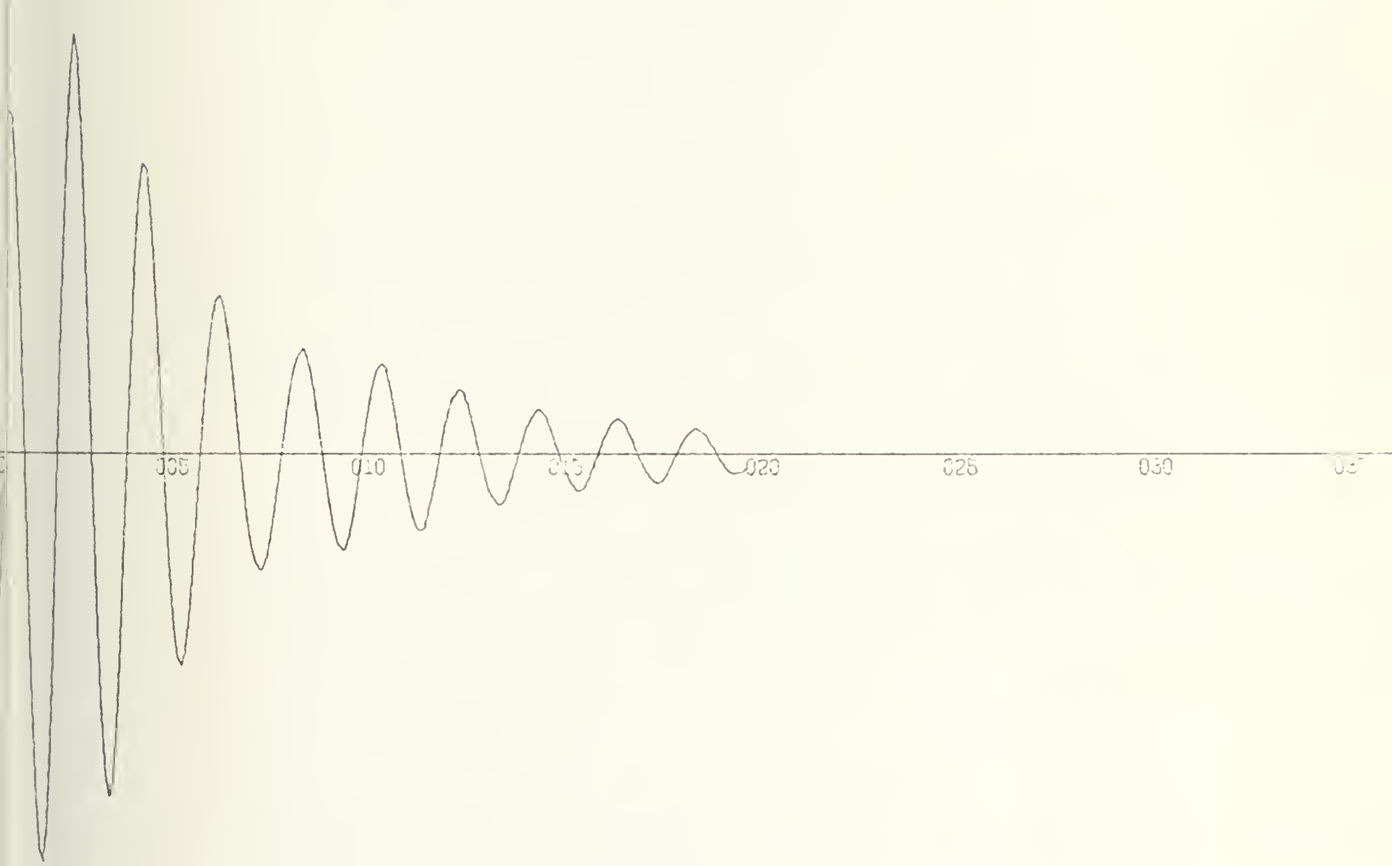
-SCALE=5.00E+01 UNITS INCH.
ROGRAM 3, 2. STRAIGHT RUN AT 20 KNOTS
LOT IS THRUST STARBOARD VERSUS TIME

PLOT 17



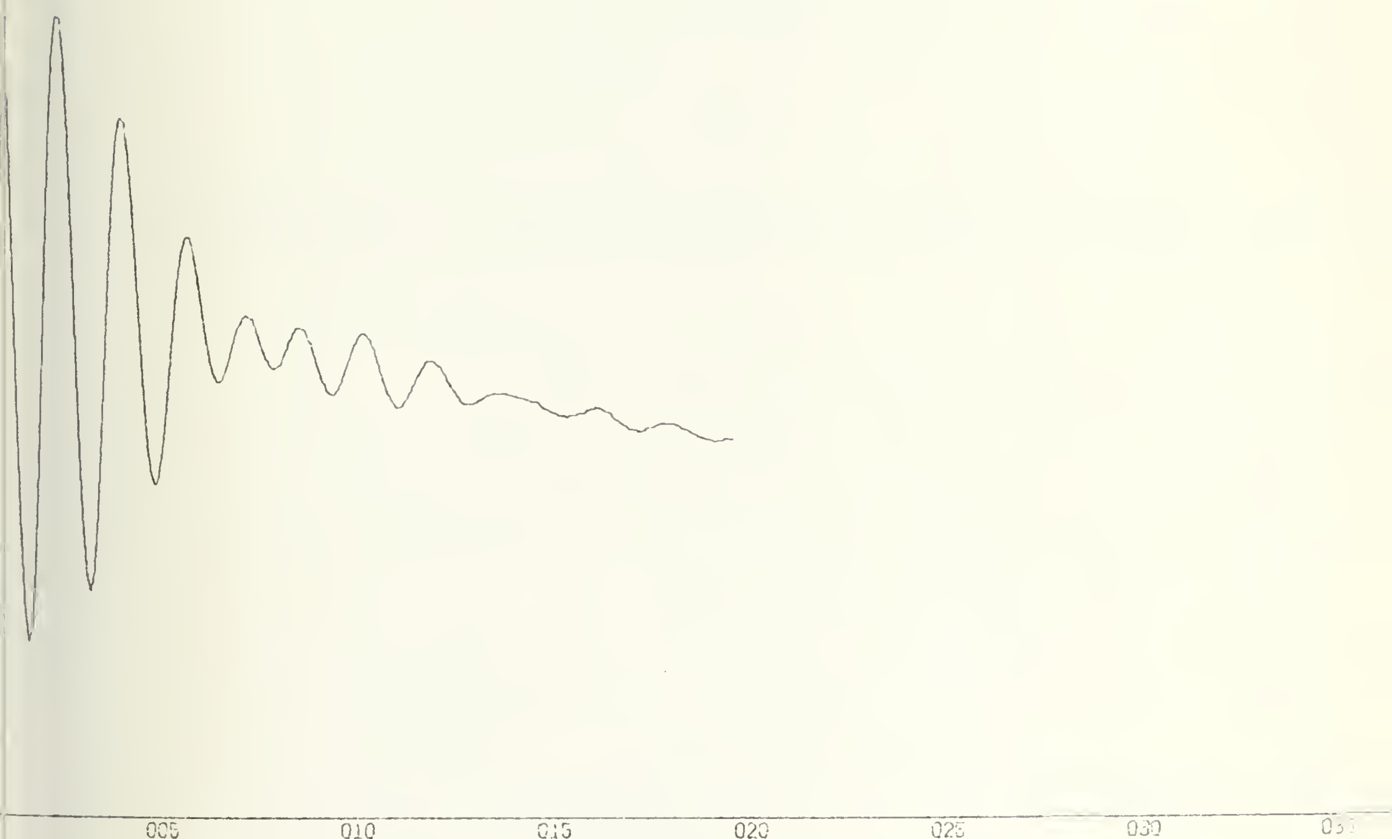
-SCALE=5.00E+00 UNITS INCH.
-SCALE=5.00E-01 UNITS INCH.
ROGRAM 2, TURN AT 20 KNOTS WITHOUT R.D.
LOT IS PITCH ANGLE VERSUS TIME

PLOT 18



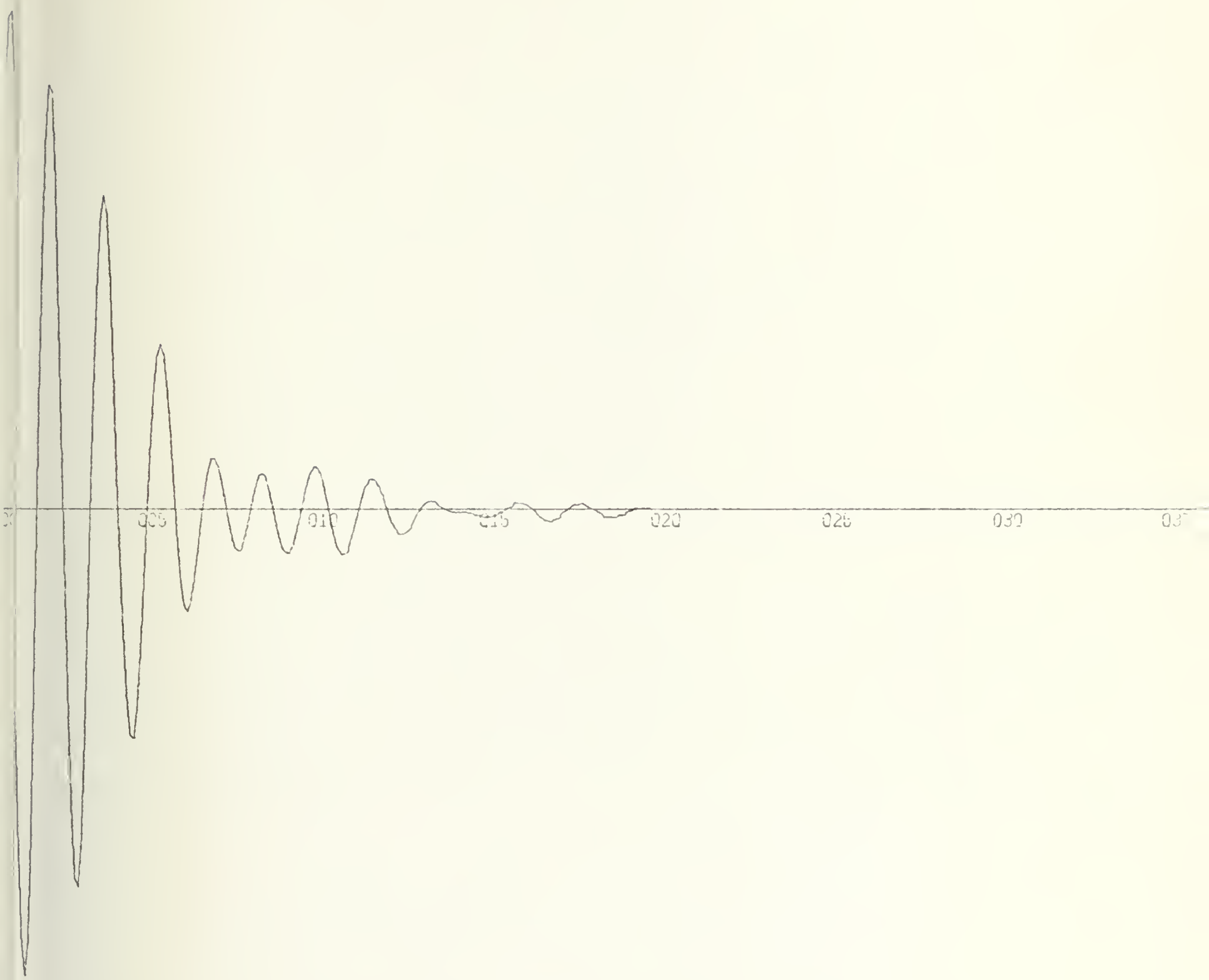
-SCALE=5.00E+00 UNITS INCH.
-SCALE=2.00E+00 UNITS INCH.
ROGRAM 2, TURN AT 20 KNOTS WITHOUT R.D
LOT IS PITCH RATE VERSUS TIME

PLOT 19



SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E+00 UNITS INCH.
RØGRAM 2, TURN AT 20 KNOTS WITHOUT R.D.
LØT IS RØLL ANGLE VERSUS TIME

PLOT 20



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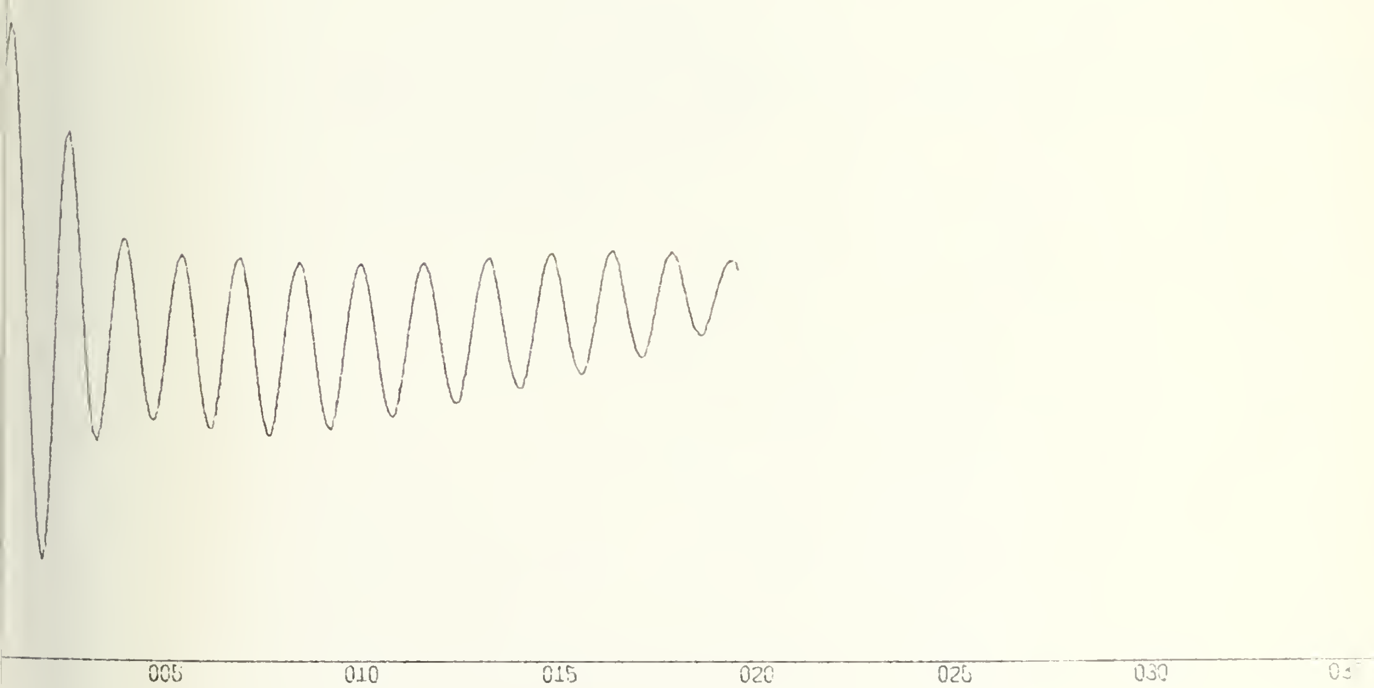
YSCALE=5.00E+00 UNITS INCH.
PRØGRAM 2, TURN AT 20 KNØTS WITHØUT R.D.
PLØT IS ROLL RATE VERSUS TIME

PLOT 21



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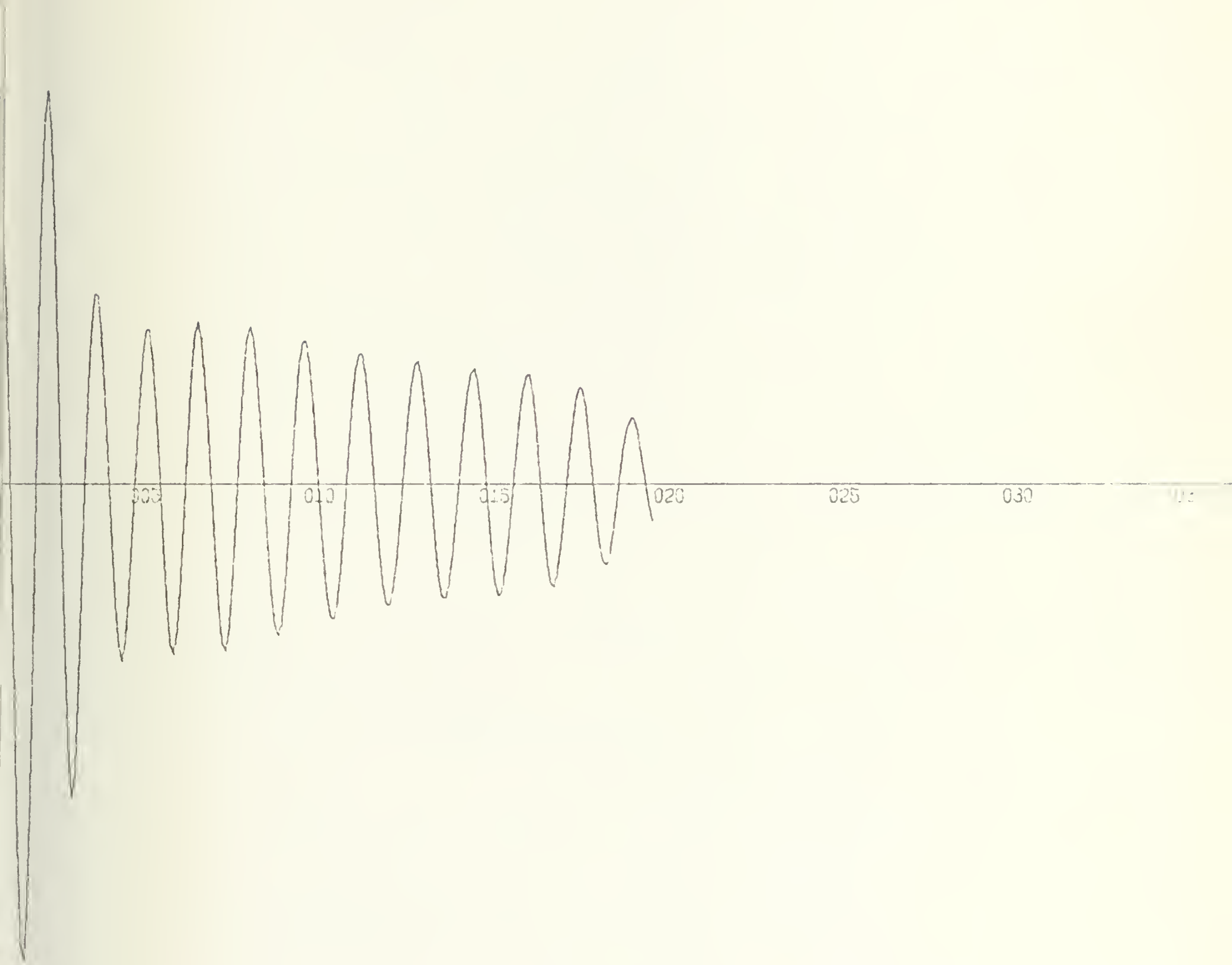
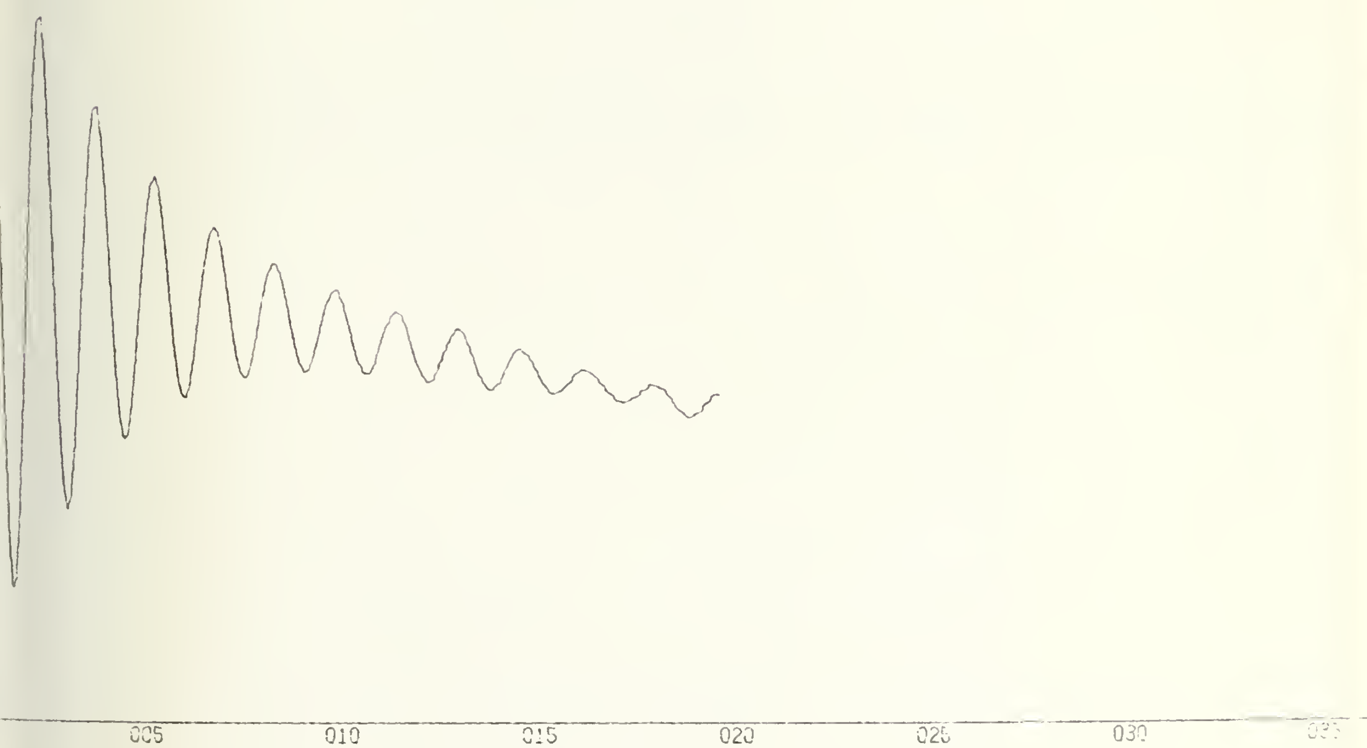
ROGRAM 3, TURN AT 20 KNOTS WITHOUT R.D
LOT IS PITCH ANGLE VERSUS TIME

PLOT 22



SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITHOUT R.D
LOT IS PITCH RATE VERSUS TIME

PLOT 23



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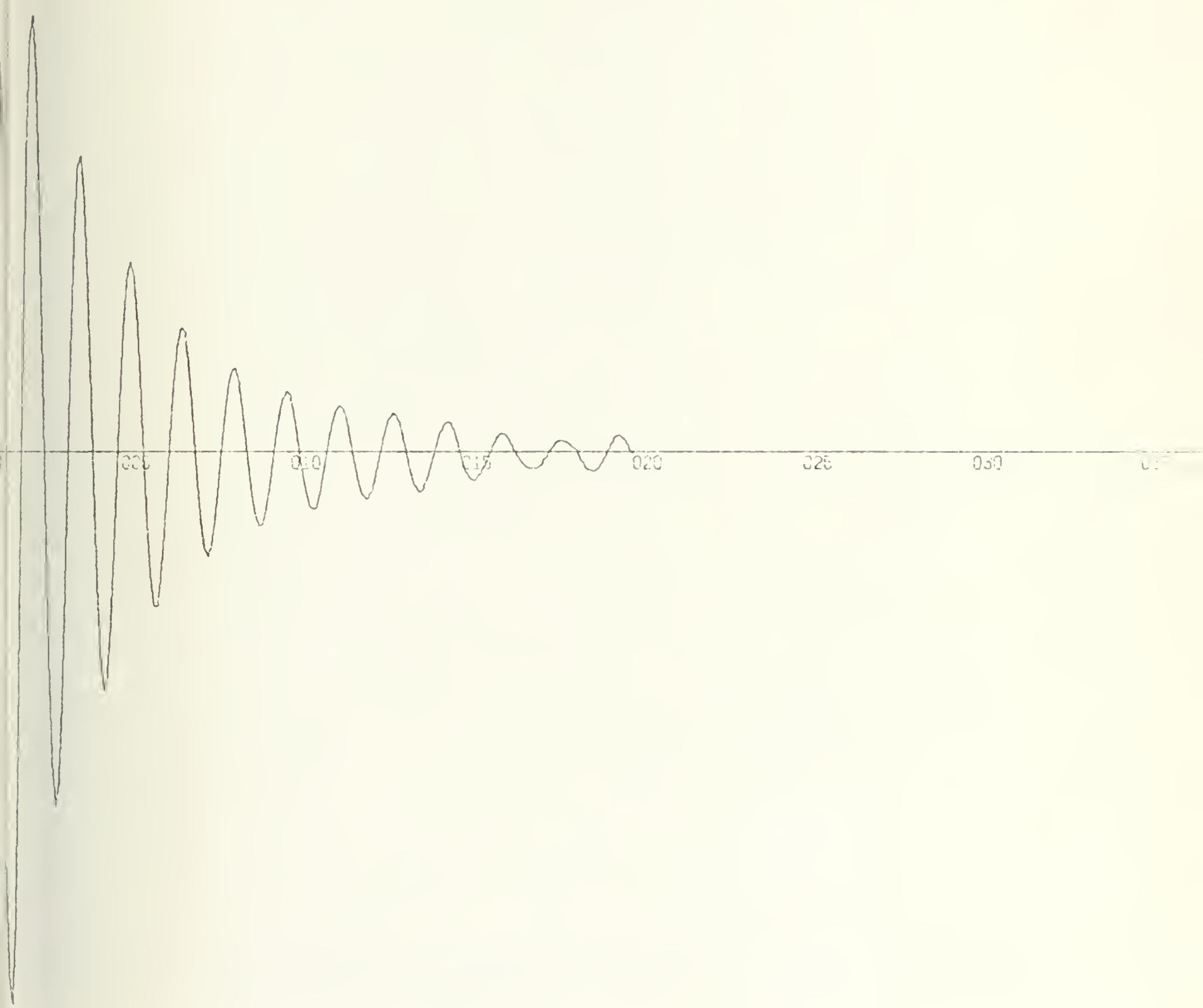
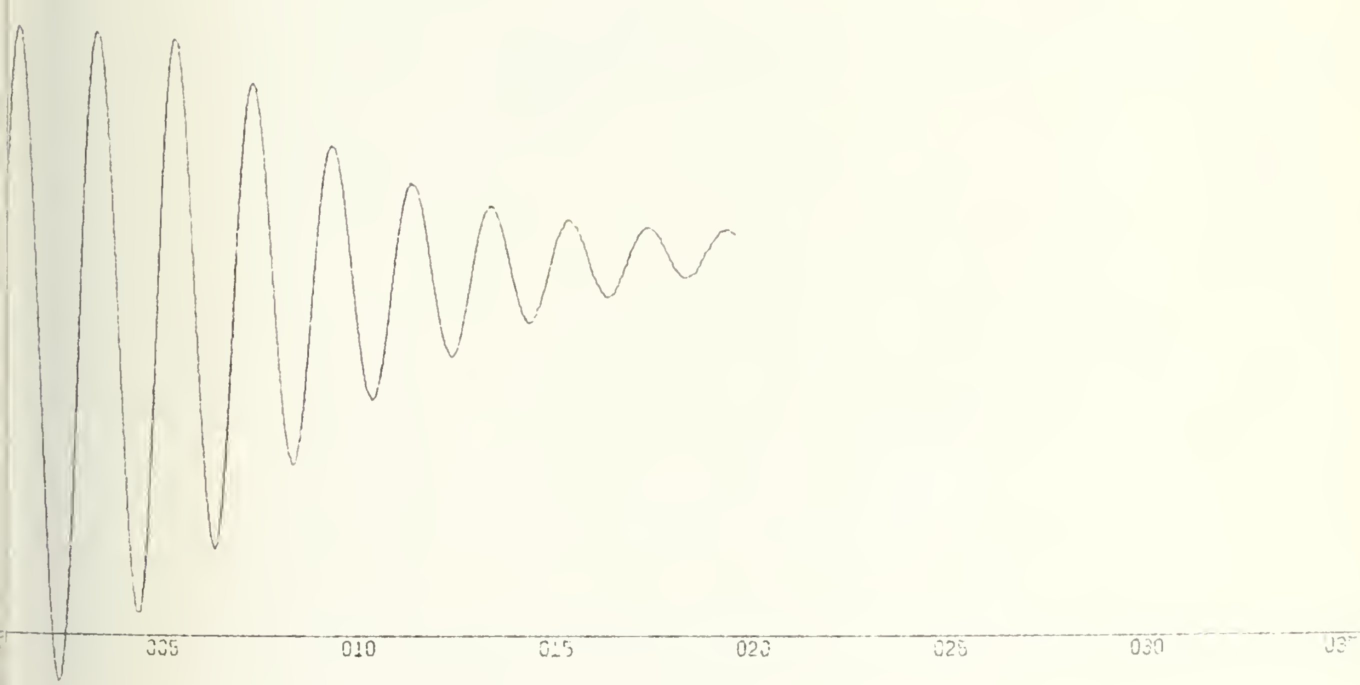
SCALE=2.00E+00 UNITS INCH.
RØGRAM 3, TURN AT 20 KNOTS WITHOUT R.D.
ØT IS RØLL ANGLE VERSUS TIME

PLOT 24



SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNØTS WITHOUT R.D.
ØT IS ROLL RATE VERSUS TIME

PLOT 25



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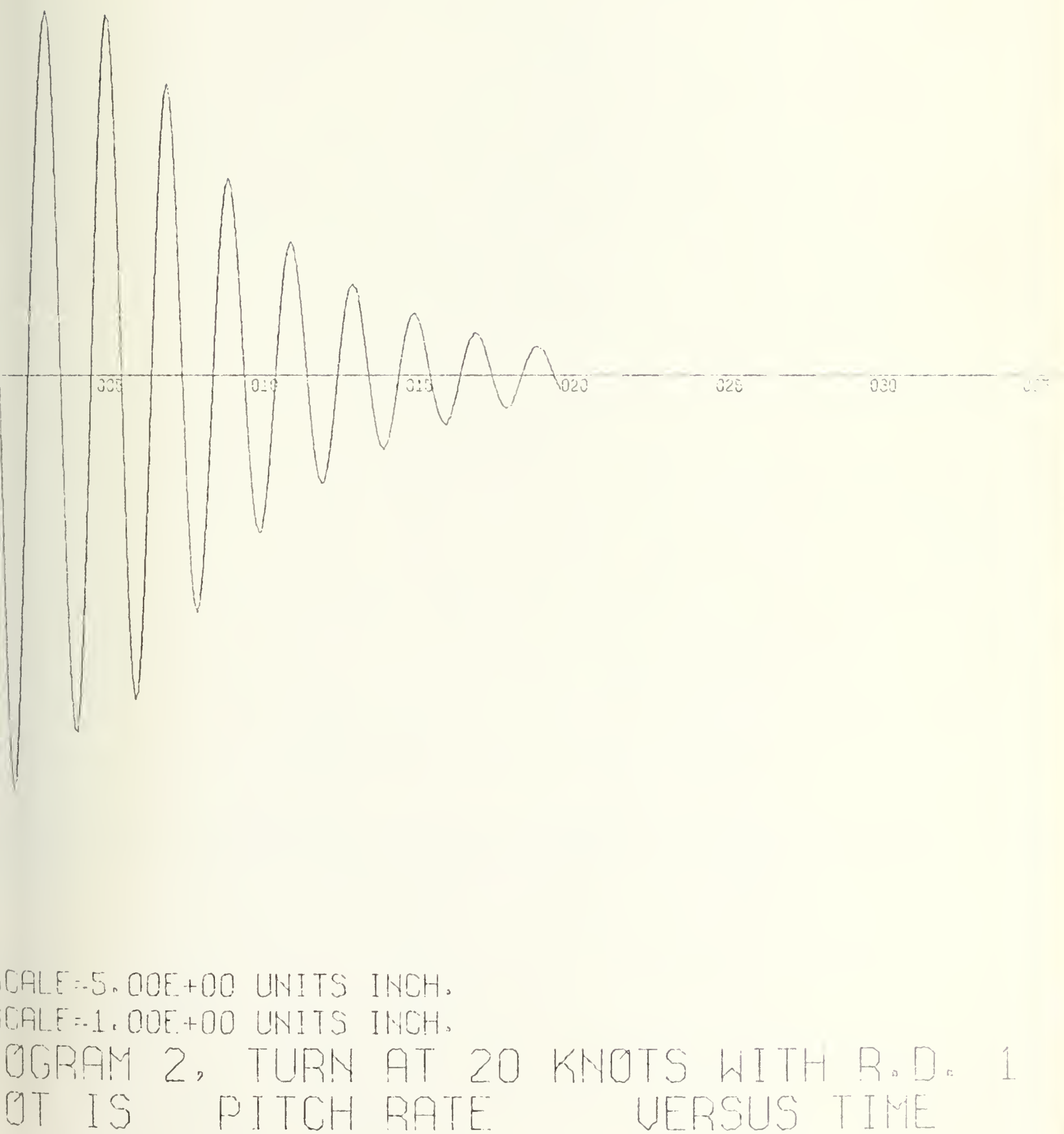
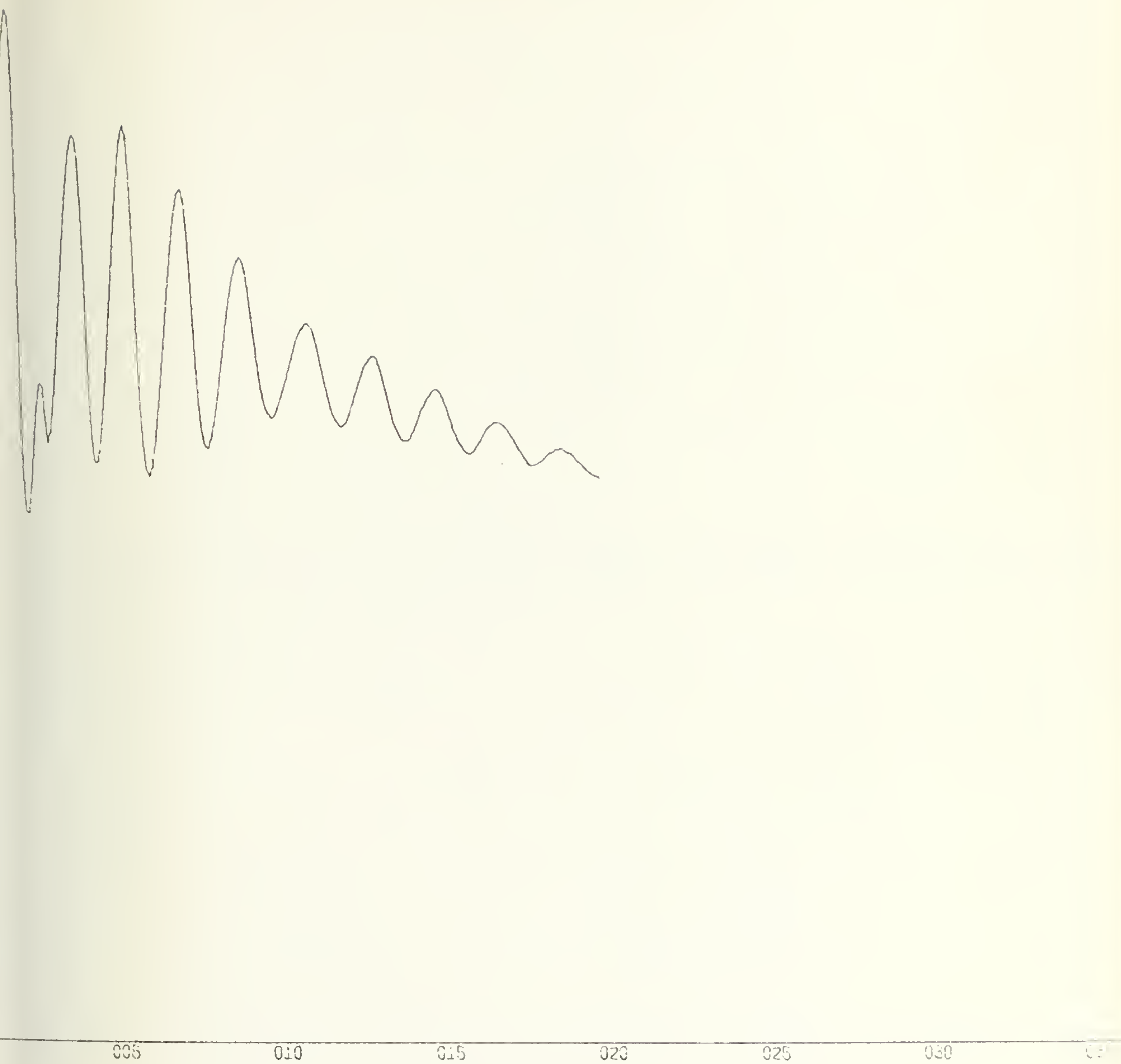
SCALE=5.00E-01 UNITS INCH.
ROGRAM 2, TURN AT 20 KNØTS WITH R.D. 1
ØT IS PITCH ANGLE VERSUS TIME


005
010
015
020
025
030
CALE=5.00E+00 UNITS INCH.
CALE=1.00E+00 UNITS INCH.
ØGRAM 2, TURN AT 20 KNØTS WITH R.D. 1
ØT IS PITCH RATE VERSUS TIME

PLOT 27



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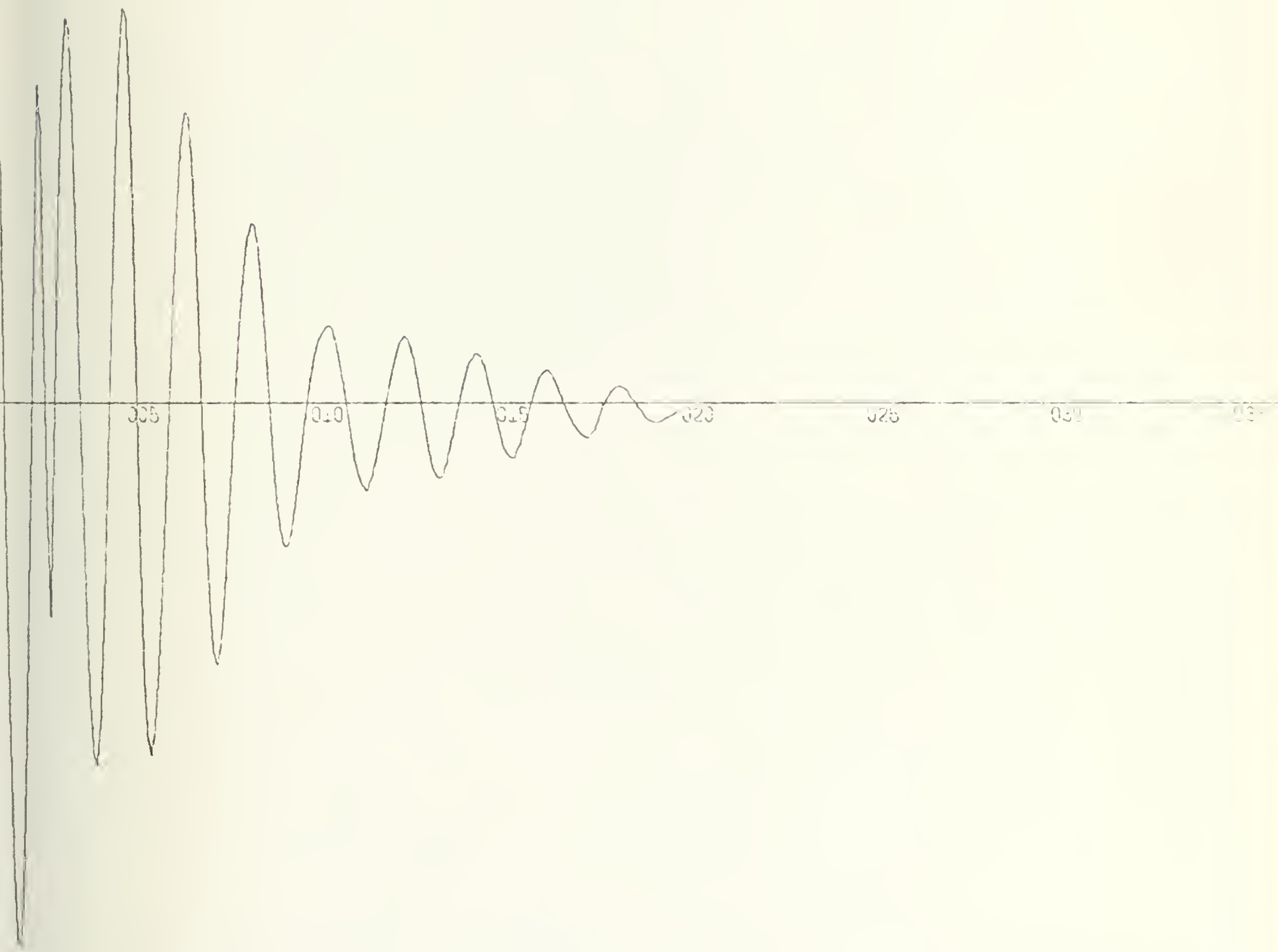
SCALE=1.00E+00 UNITS INCH.
ROGRAM 2, TURN AT 20 KNØTS WITH R.D. 1
LØT IS RØLL ANGLE VERSUS TIME

PLOT 28



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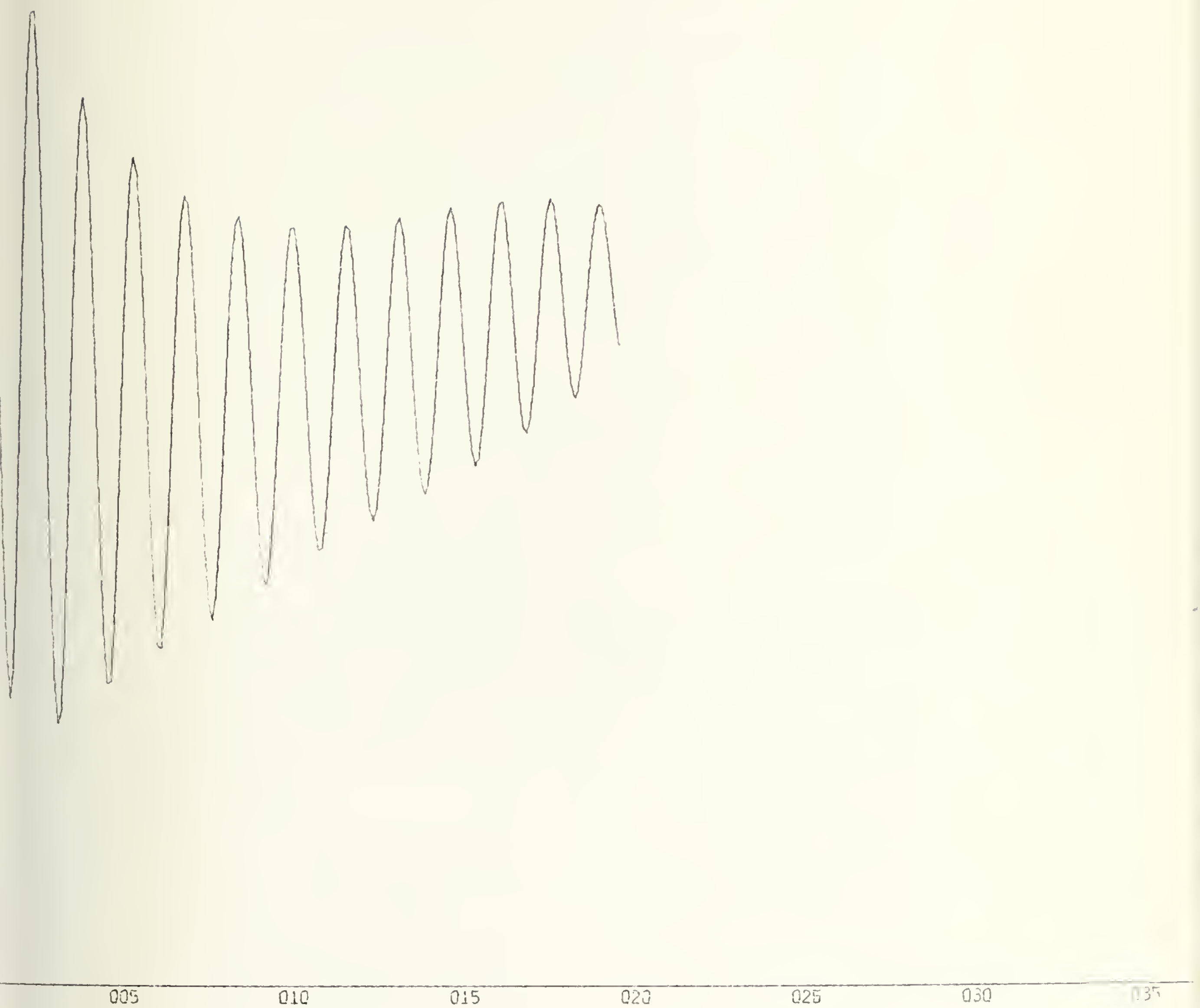
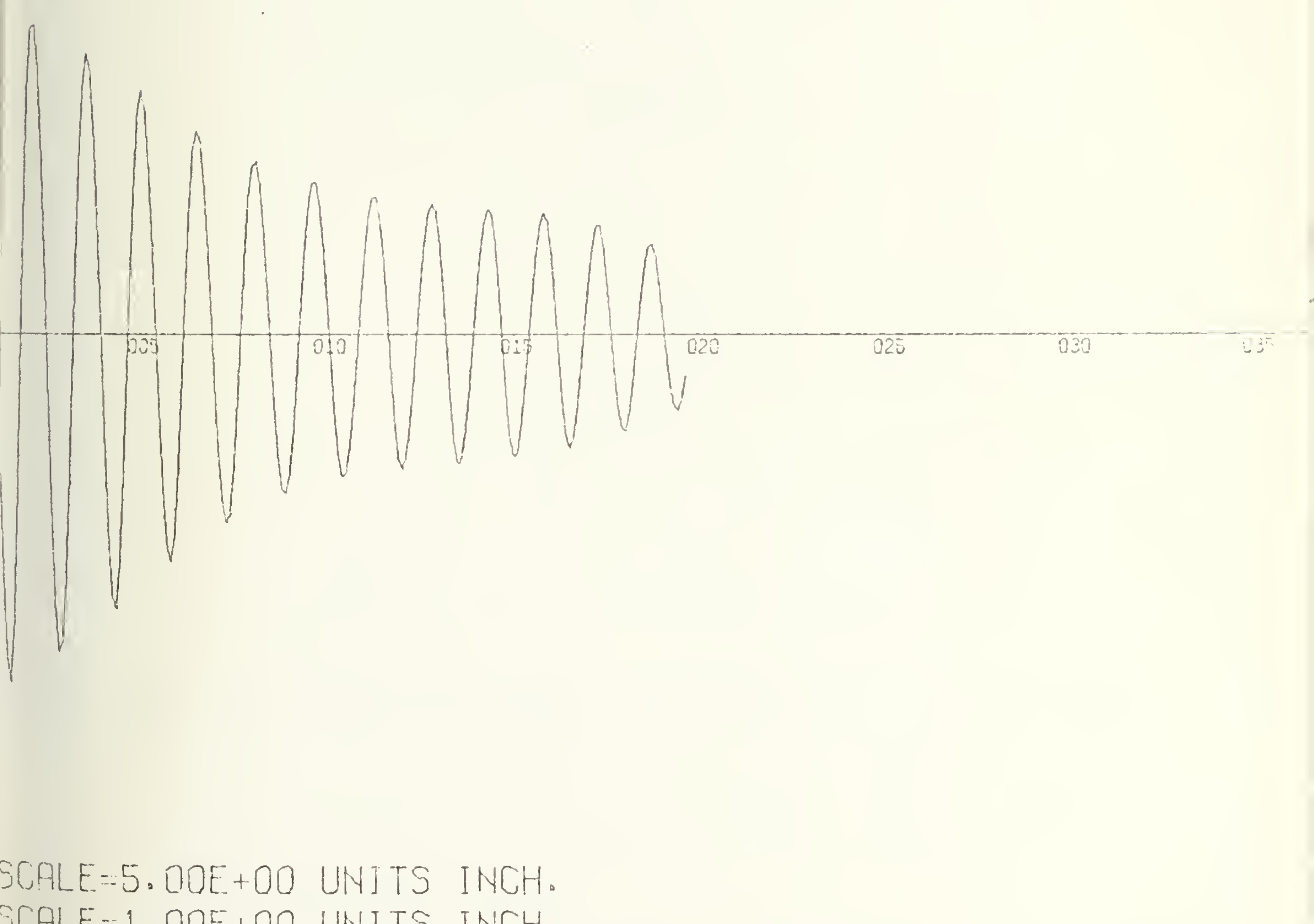
SCALE=2.00E+00 UNITS INCH.
ROGRAM 2, TURN AT 20 KNOTS WITH R.D. 1
LOT IS ROLL RATE VERSUS TIME

PLOT 29



SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
OGRAM 3, TURN AT 20 KNOTS WITH R.D. 1
OT IS PITCH ANGLE VERSUS TIME

PLOT 30



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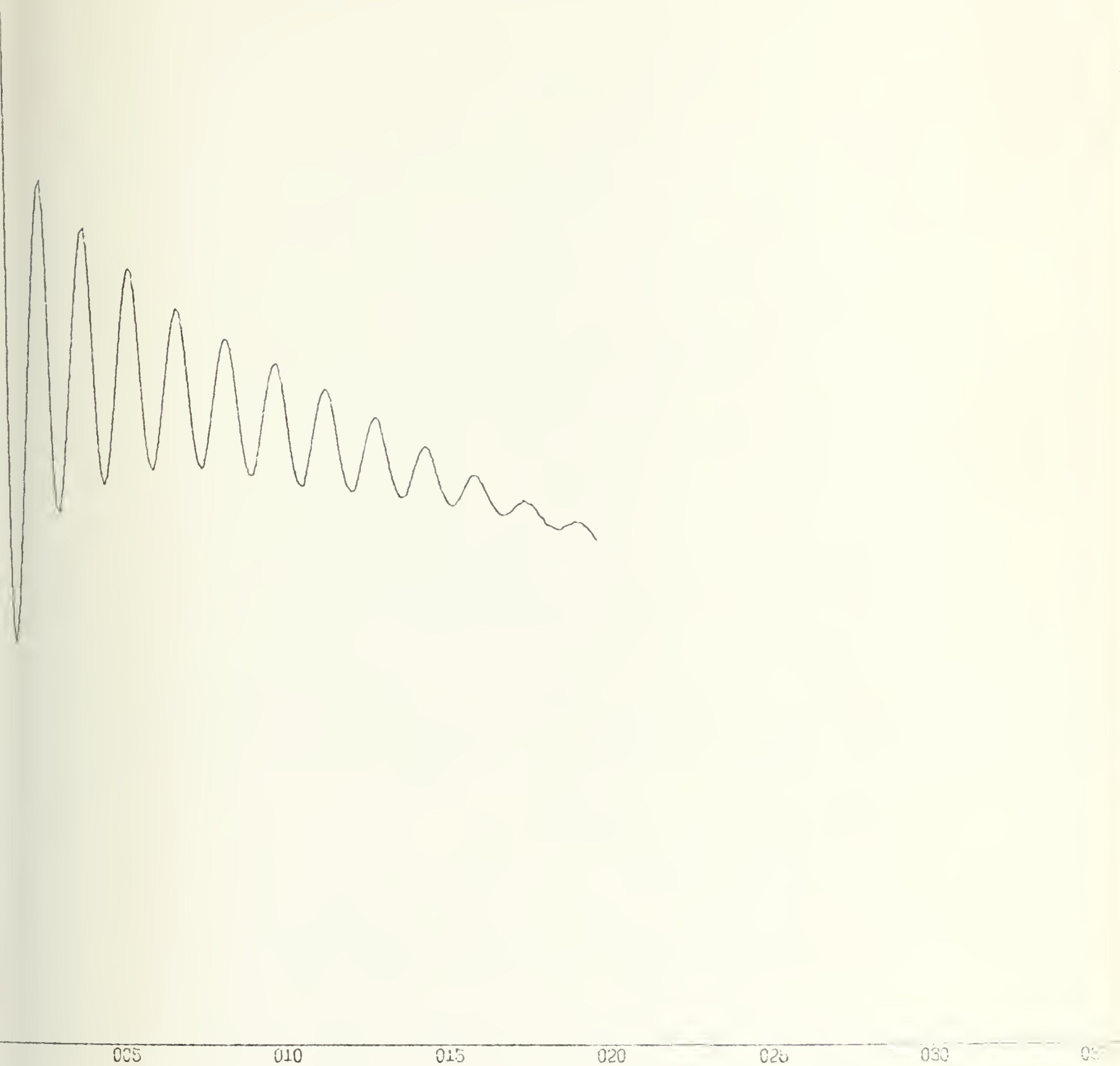
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 1
LOT IS PITCH RATE VERSUS TIME

PLOT 31



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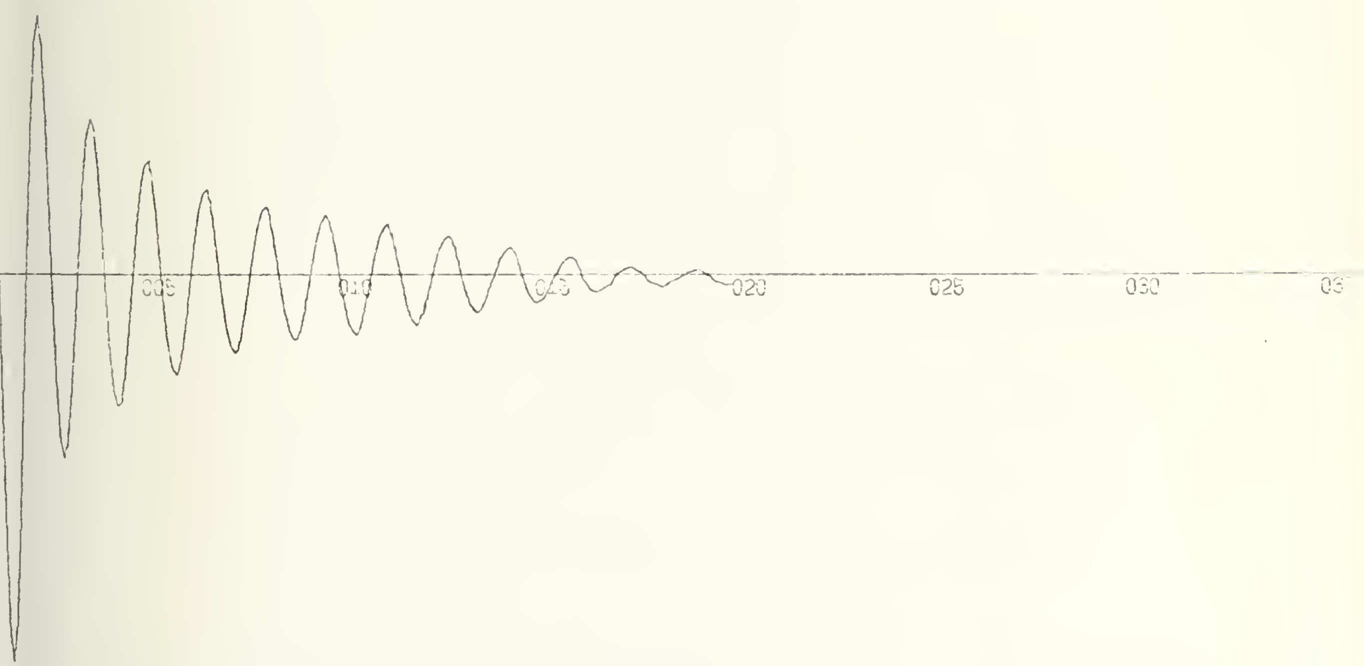
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNØTS WITH R.D. 1
LØT IS RØLL ANGLE VERSUS TIME

PLOT 32



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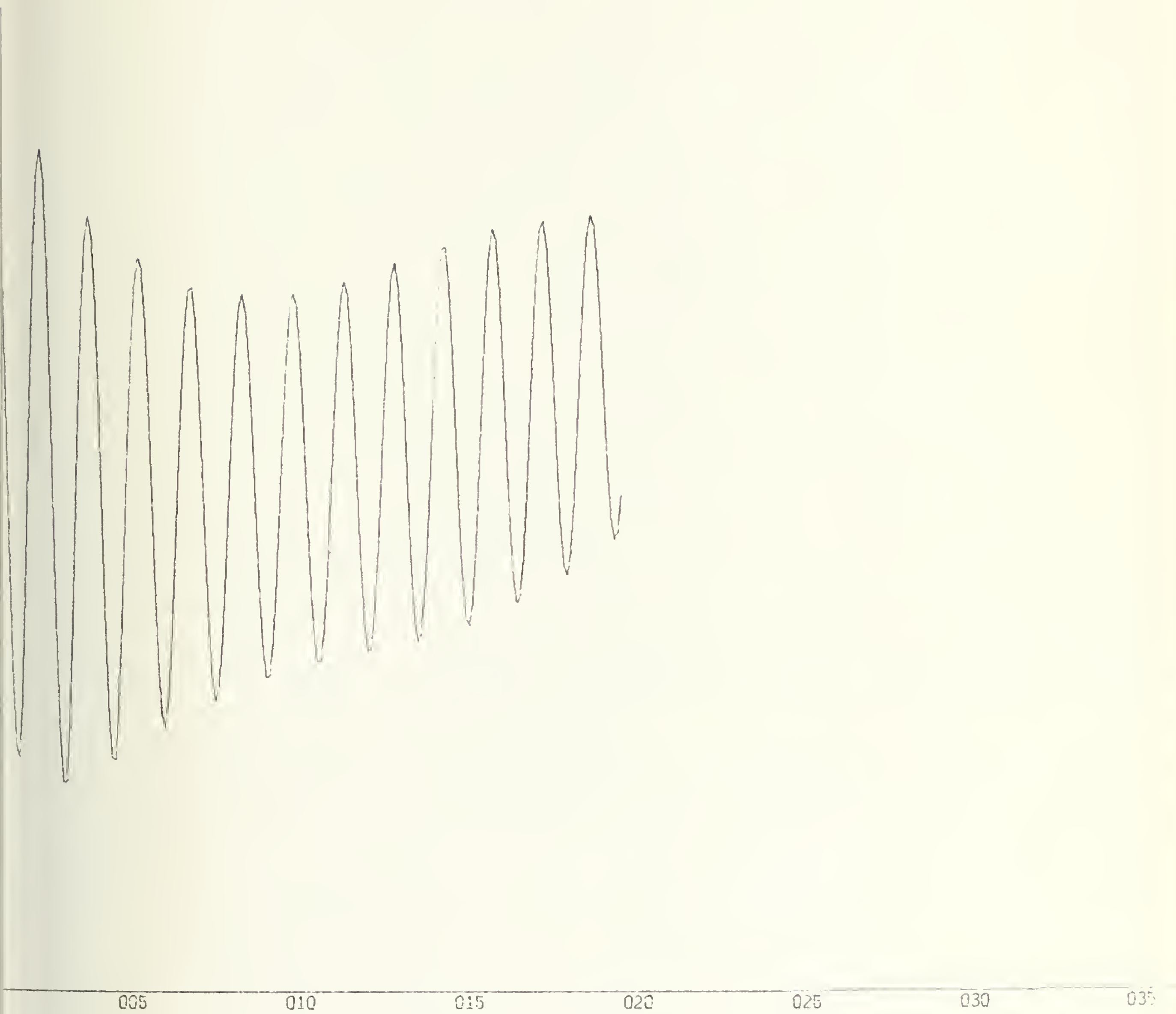
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 1
LOT IS ROLL RATE VERSUS TIME

PLOT 33



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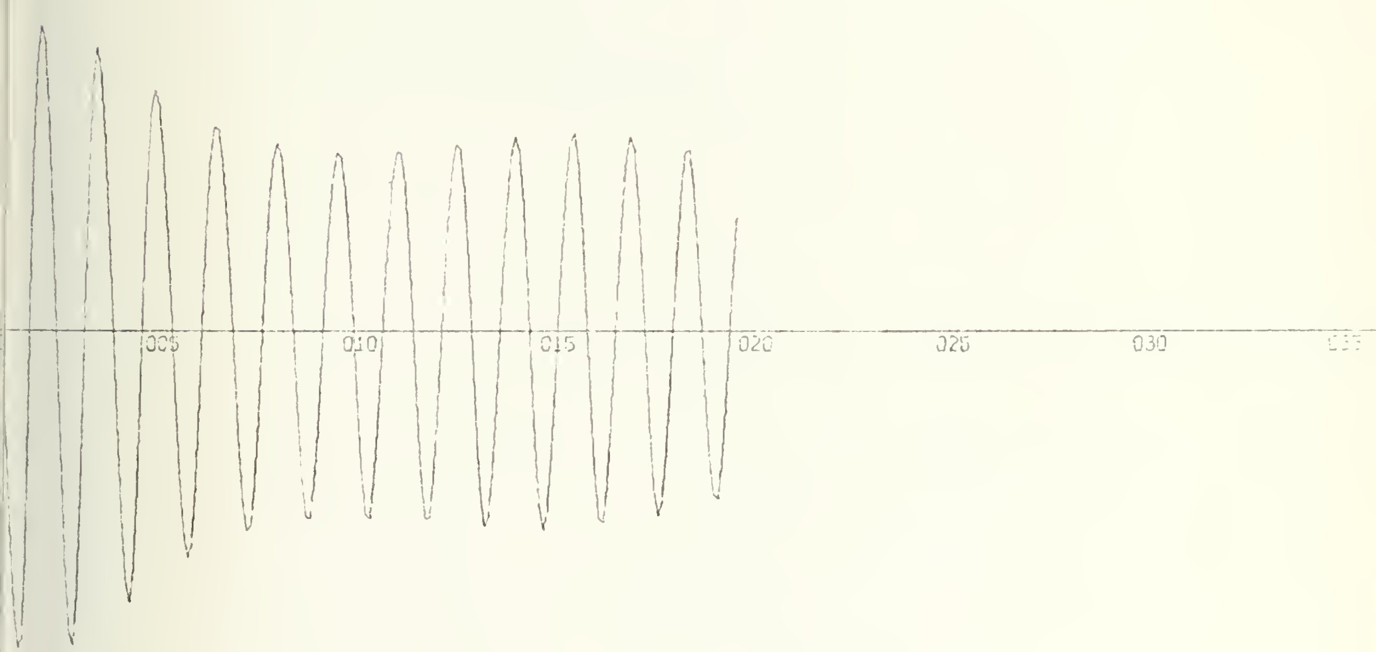
SCALE=2.00E-01 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 2
OT IS PITCH ANGLE VERSUS TIME

PLOT 34



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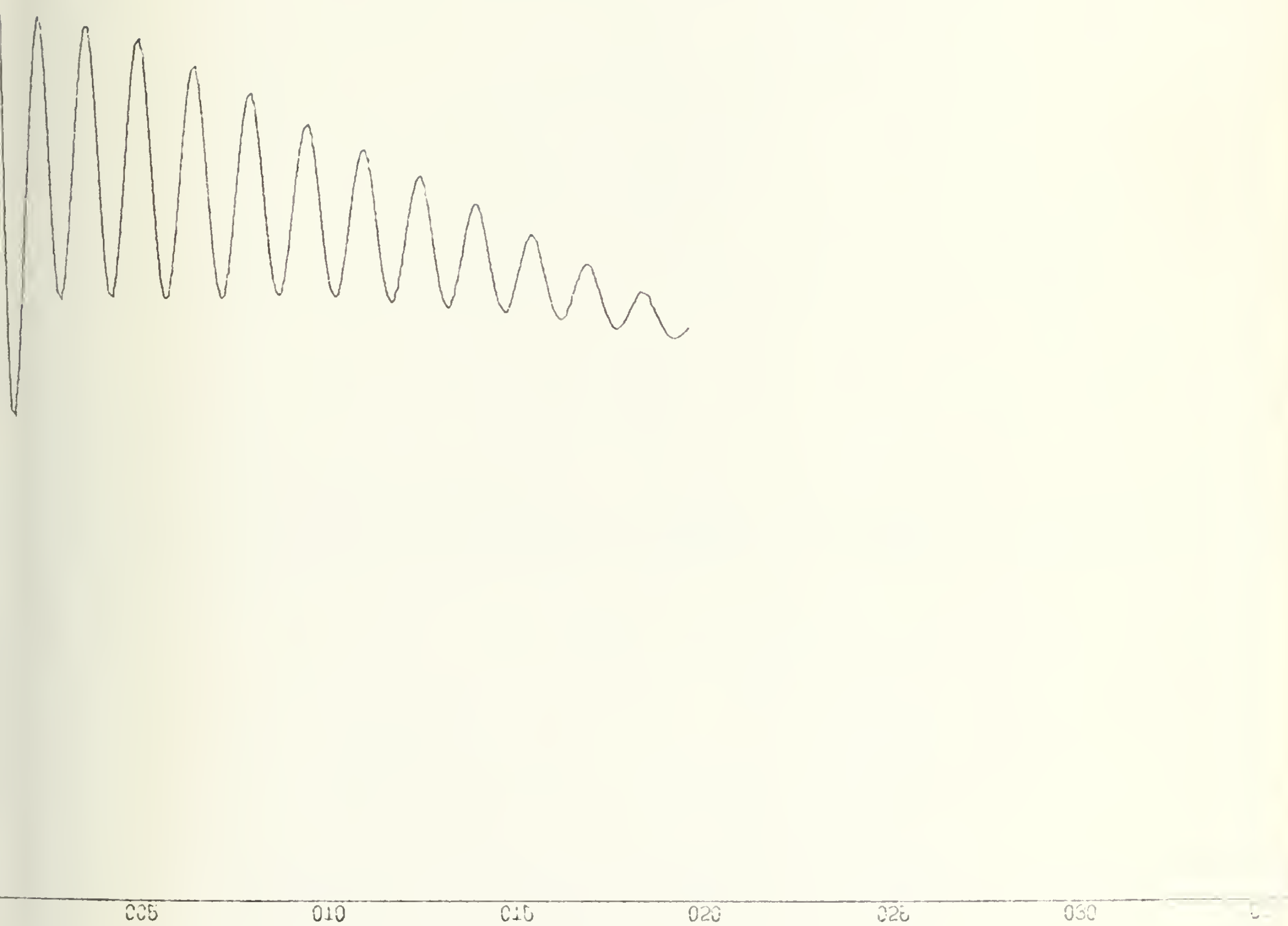
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 2
LOT IS PITCH RATE VERSUS TIME

PLOT 35



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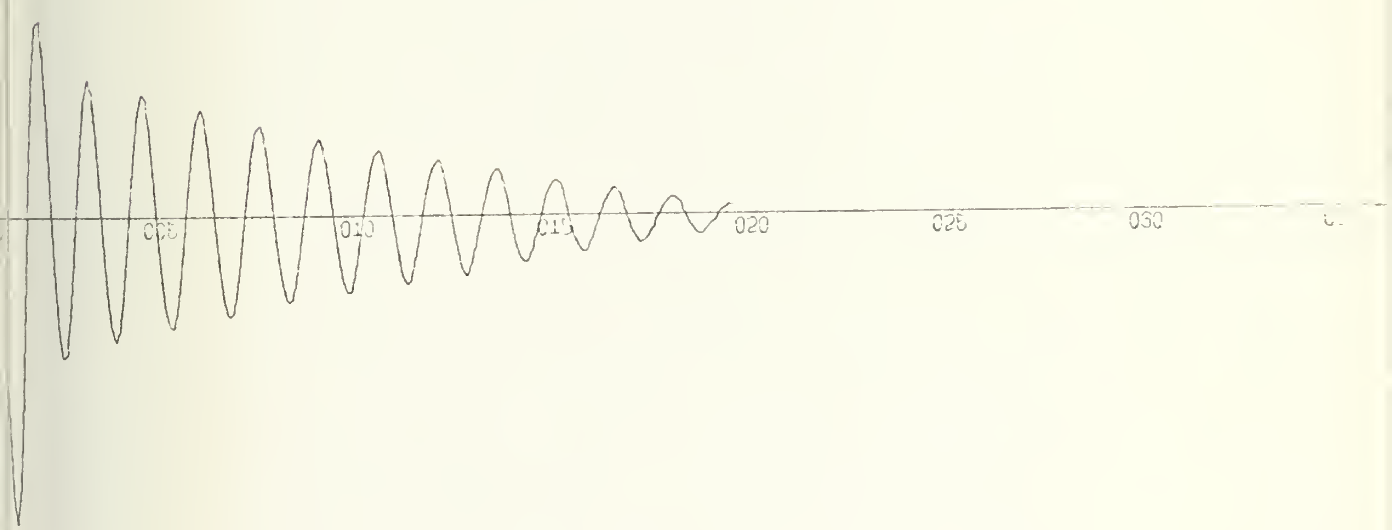
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 2
LOT IS ROLL ANGLE VERSUS TIME

PLOT 36



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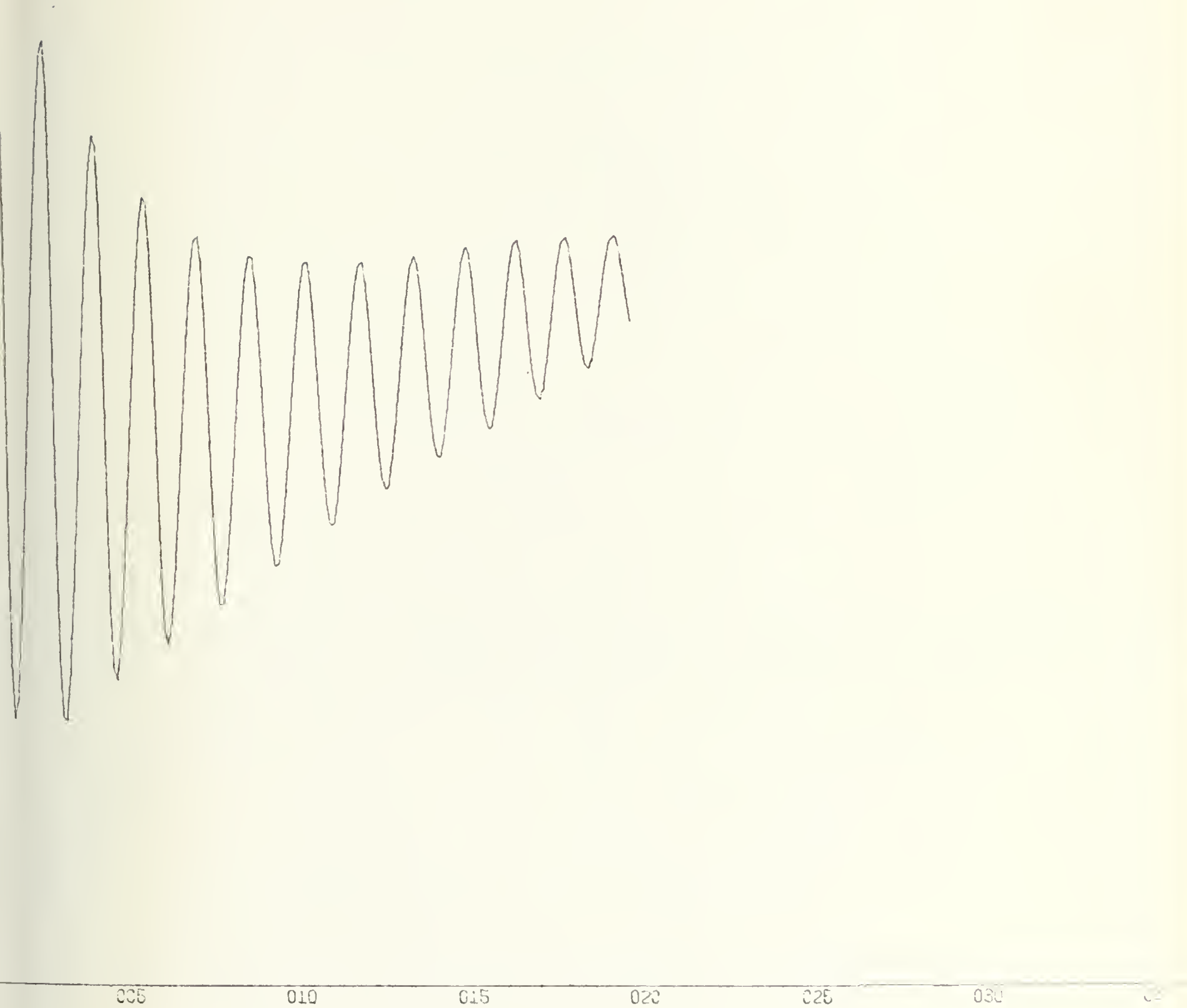
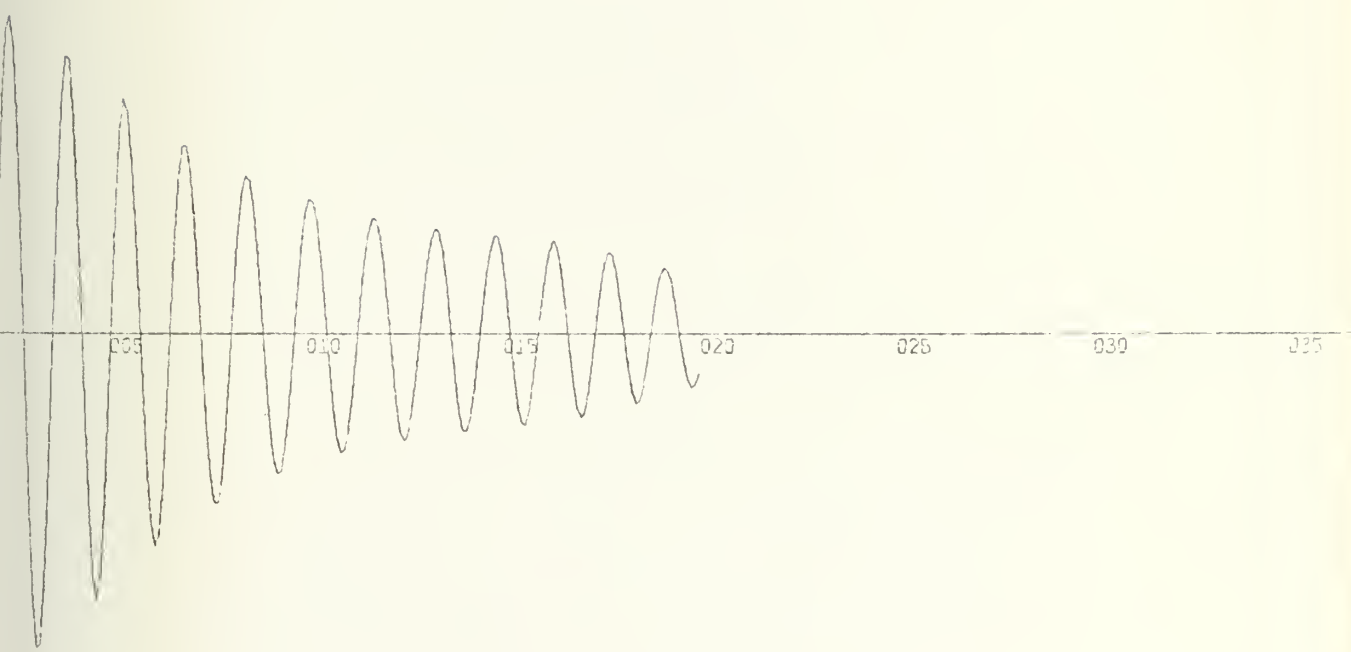
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 2
OT IS ROLL RATE VERSUS TIME



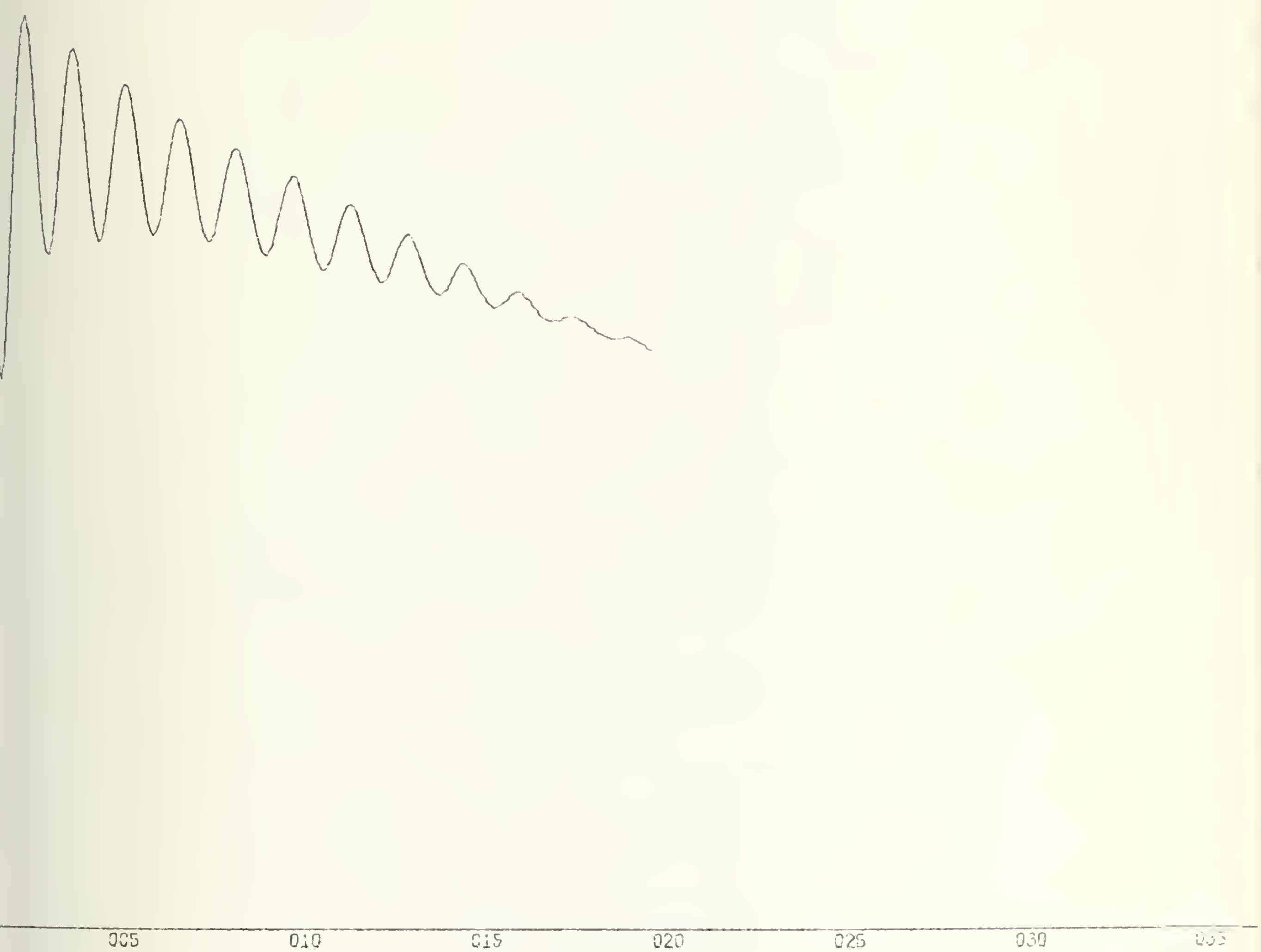
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 3
LOT IS PITCH ANGLE VERSUS TIME

PLOT 38



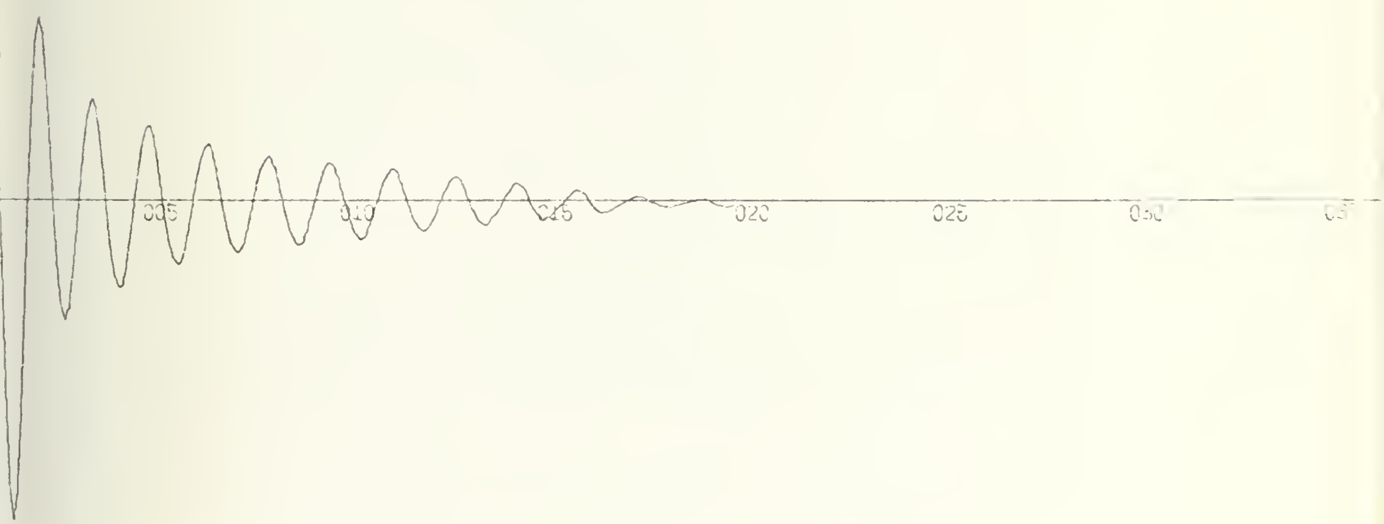
CALE=-5.00E+00 UNITS INCH.
CALE=1.00E+00 UNITS INCH.
ØGRAM 3, TURN AT 20 KNØTS WITH R.D. 3
ØT IS PITCH RATE VERSUS TIME

PLOT 39



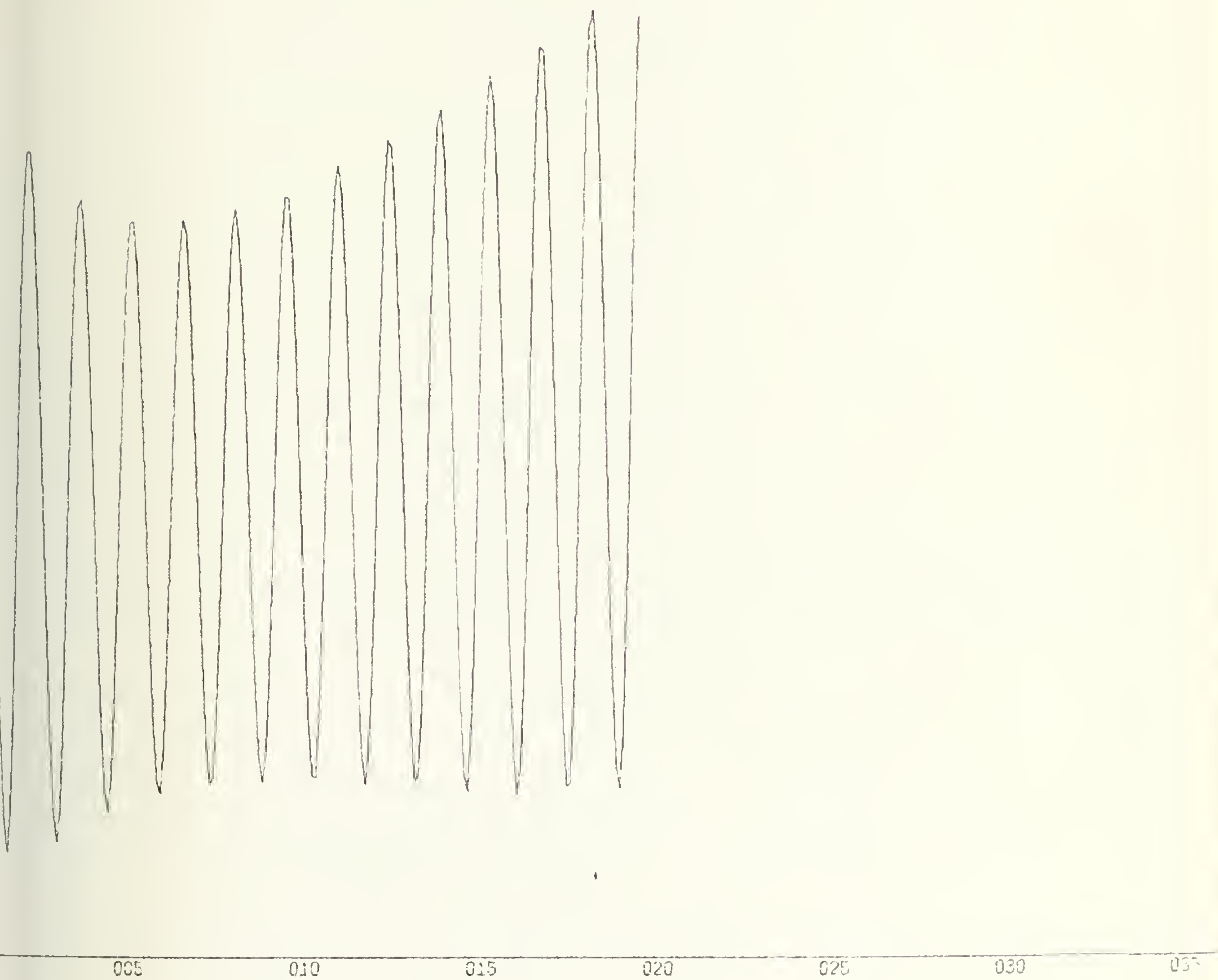
CALE=5.00E+00 UNITS INCH.
CALE=1.00E+00 UNITS INCH.
OGRAM 3. TURN AT 20 KNOTS WITH R.D. 3
OT IS ROLL ANGLE . VERSUS TIME

PLOT 40



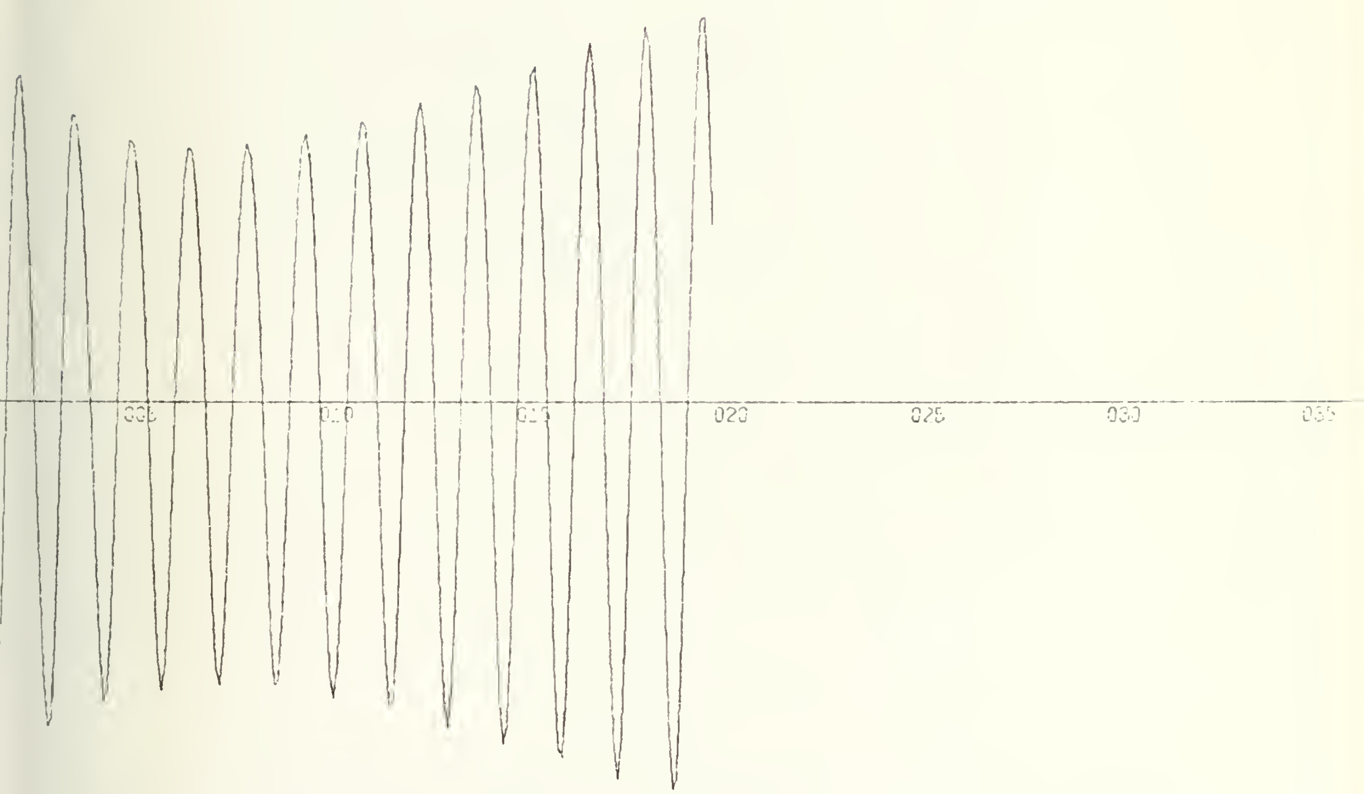
SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 3
LØT IS ROLL RATE VERSUS TIME

PLOT 41



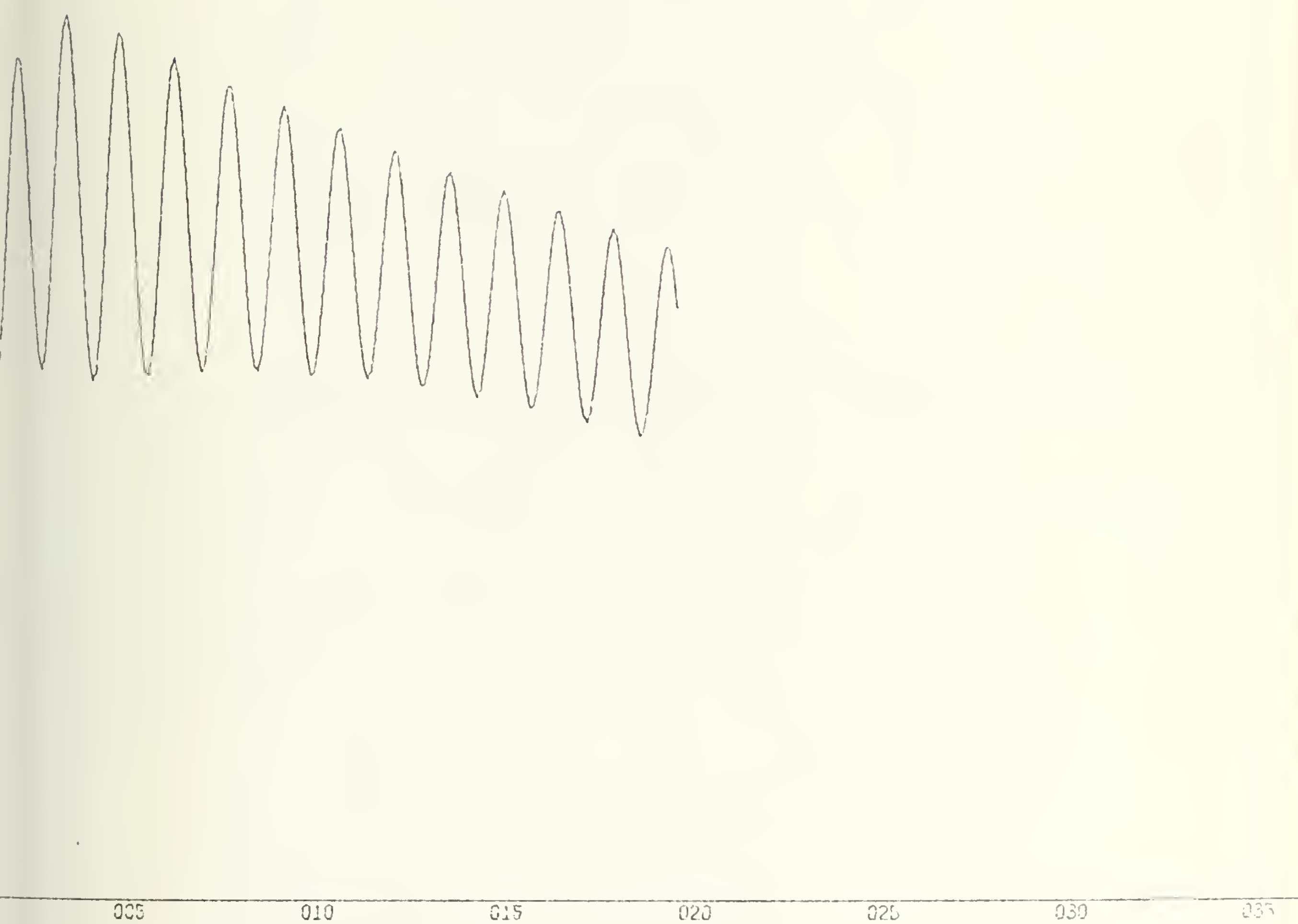
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
ØGRAM 3, TURN AT 20 KNØTS WITH R.D. 4
ØT IS PITCH ANGLE VERSUS TIME

PLOT 42



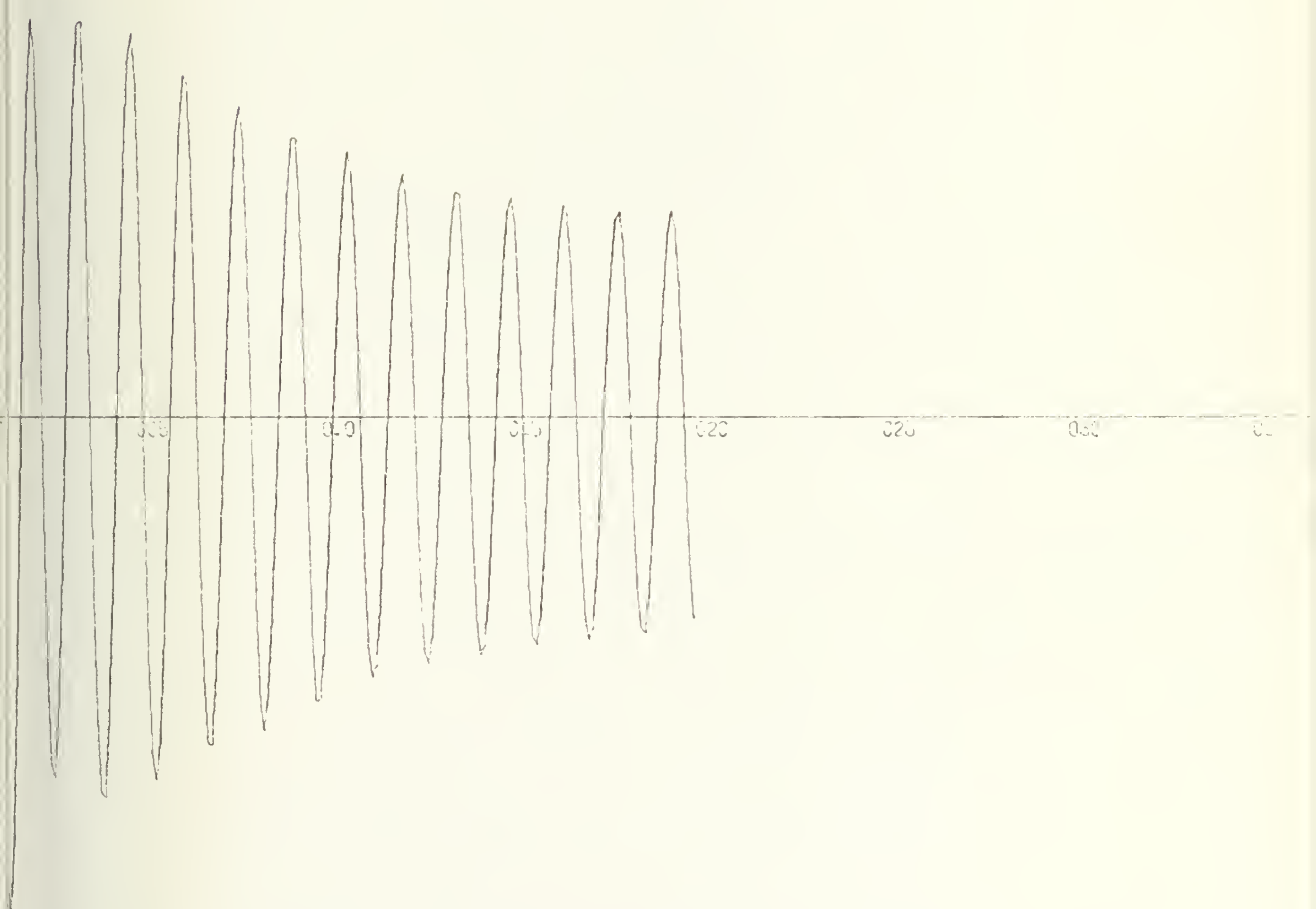
CALE=5.00E+00 UNITS INCH.
CALE=1.00E+00 UNITS INCH.
ØGRAM 3, TURN AT 20 KNØTS WITH R.D. 4
OT IS PITCH RATE VERSUS TIME

PLOT 43



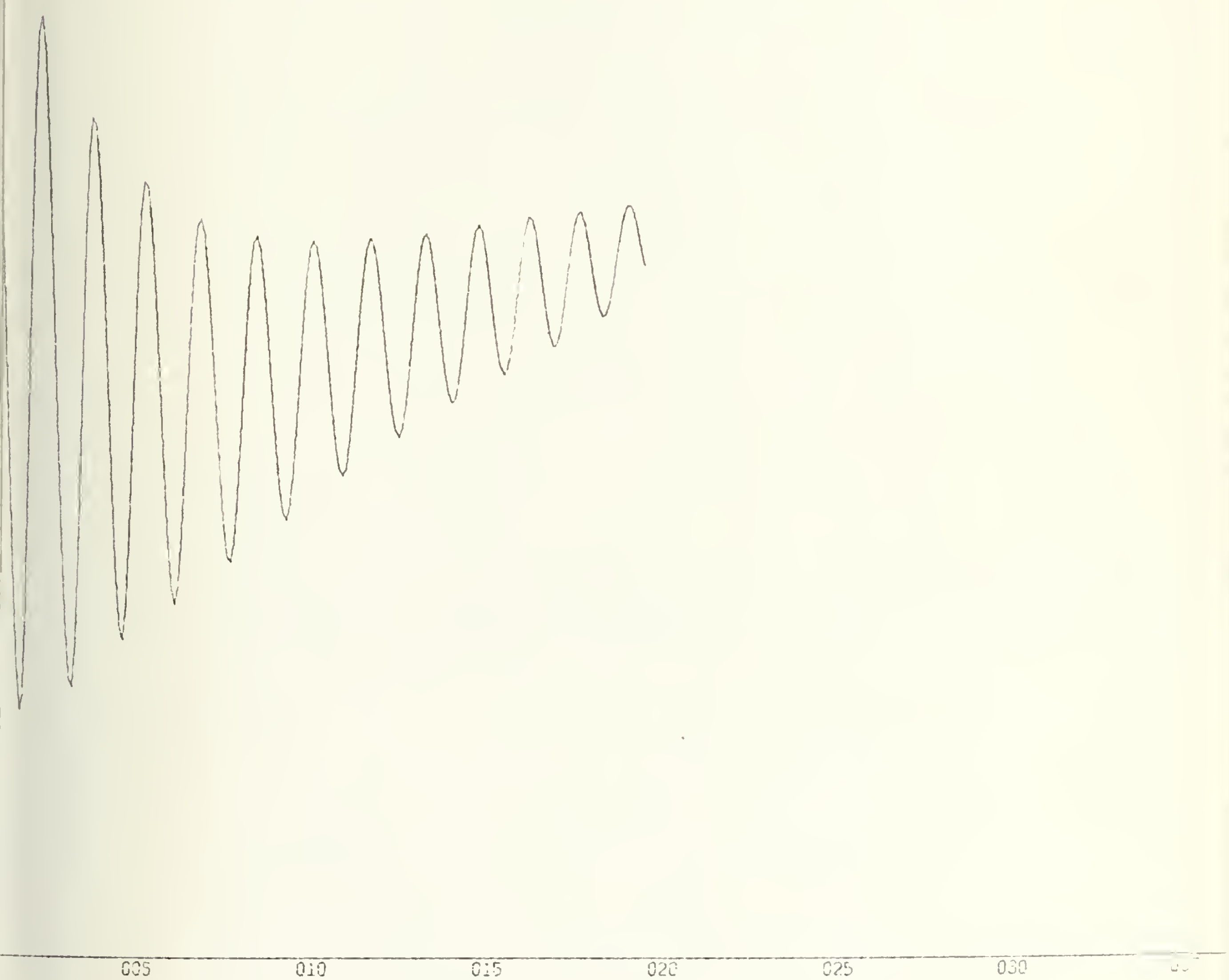
CALE=5.00E+00 UNITS INCH.
CALE=1.00E+00 UNITS INCH.
ØGRAM 3, TURN AT 20 KNOTS WITH R.D. 4
ØT IS RØLL ANGLE VERSUS TIME

PLOT 44



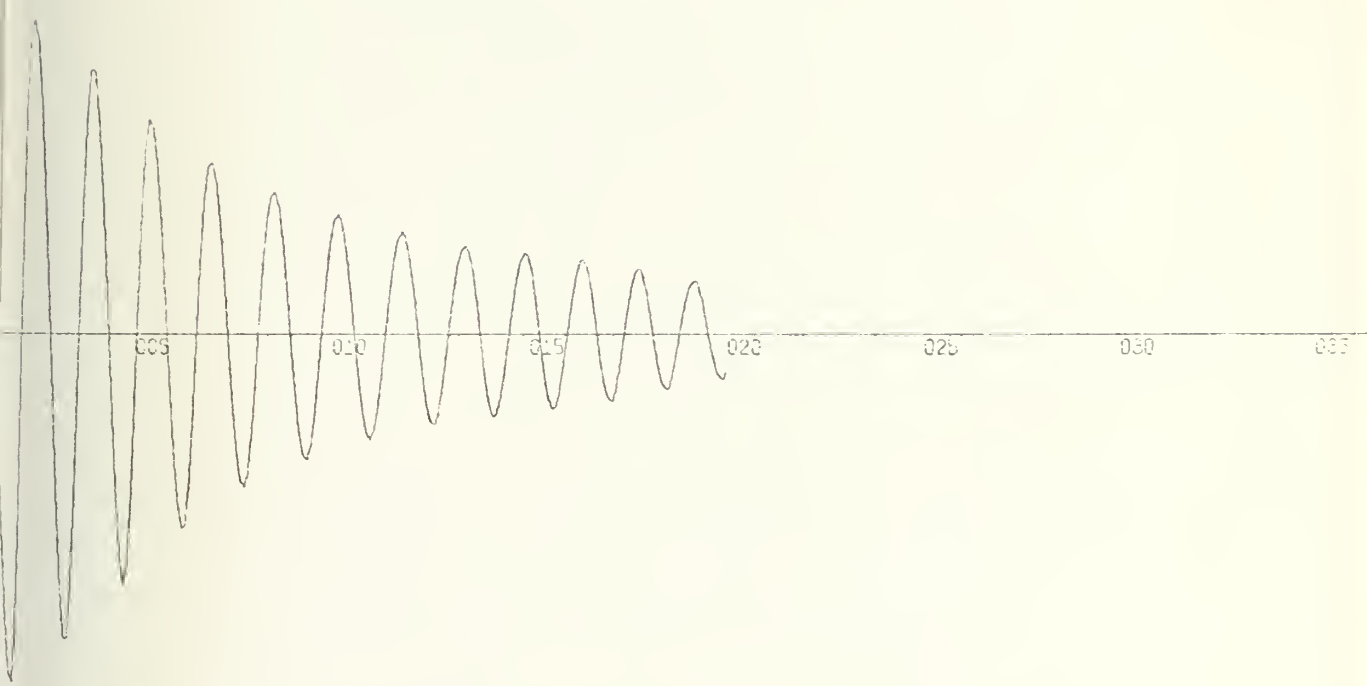
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 4
LOT IS ROLL RATE VERSUS TIME

PLOT 45



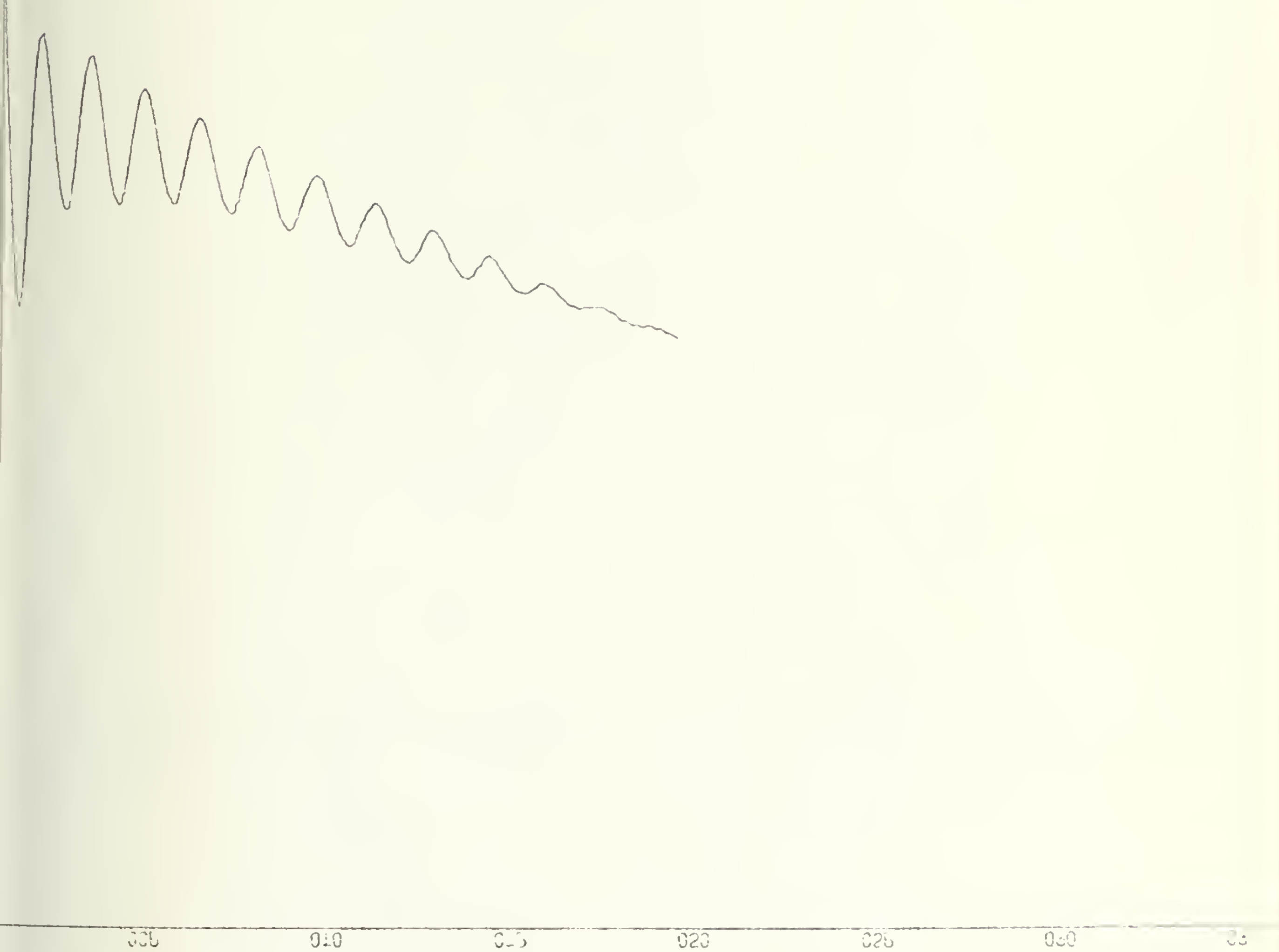
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
ROGRAM 3, TURN AT 20 KNØTS WITH R.D. 5
LOT IS PITCH ANGLE VERSUS TIME

PLOT 46



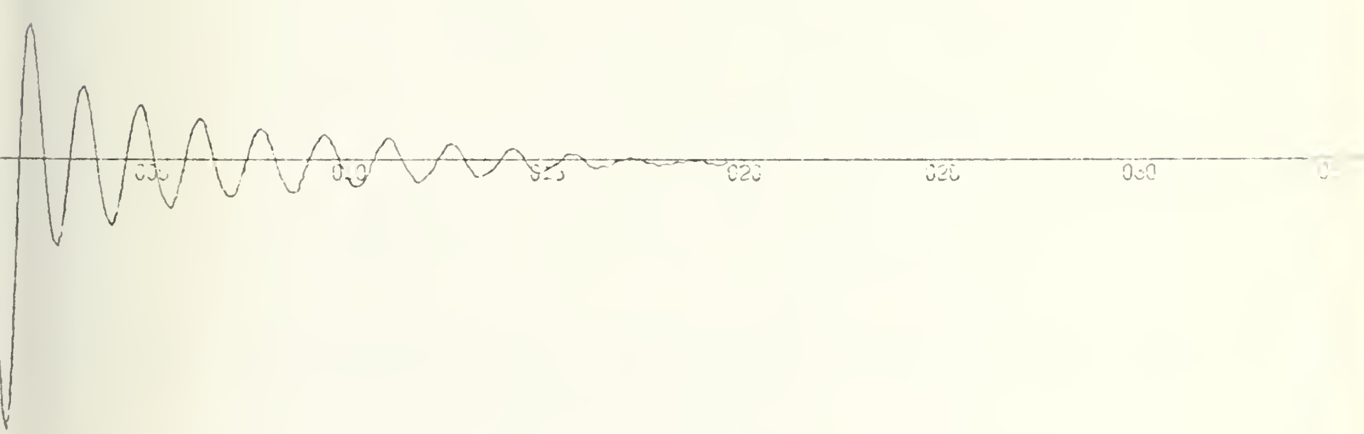
SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 5
LOT IS PITCH RATE VERSUS TIME

PLOT 47



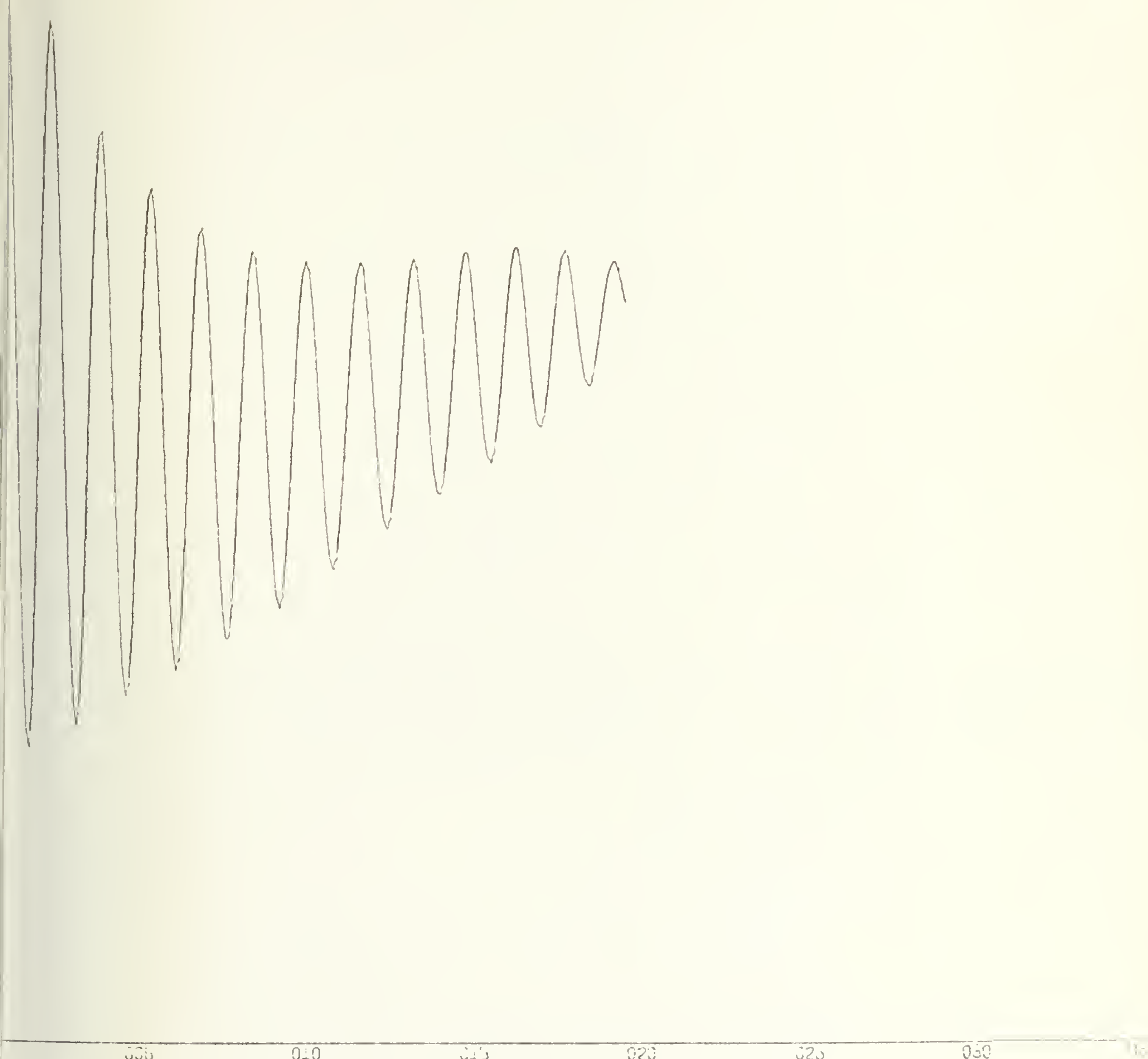
SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 5
LØT IS RØLL ANGLE VERSUS TIME

PLOT 48



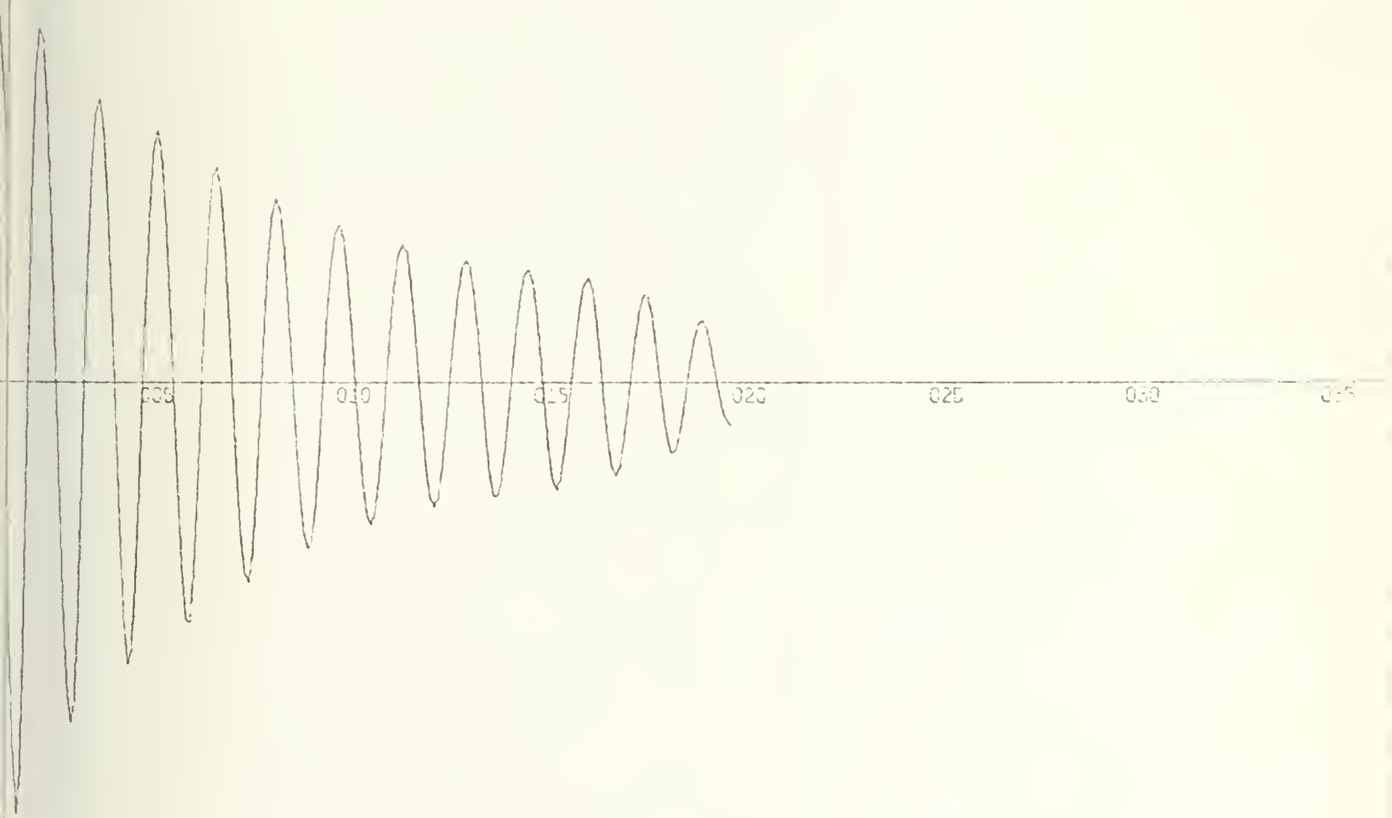
SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 5
OT IS ROLL RATE VERSUS TIME

PLOT 49



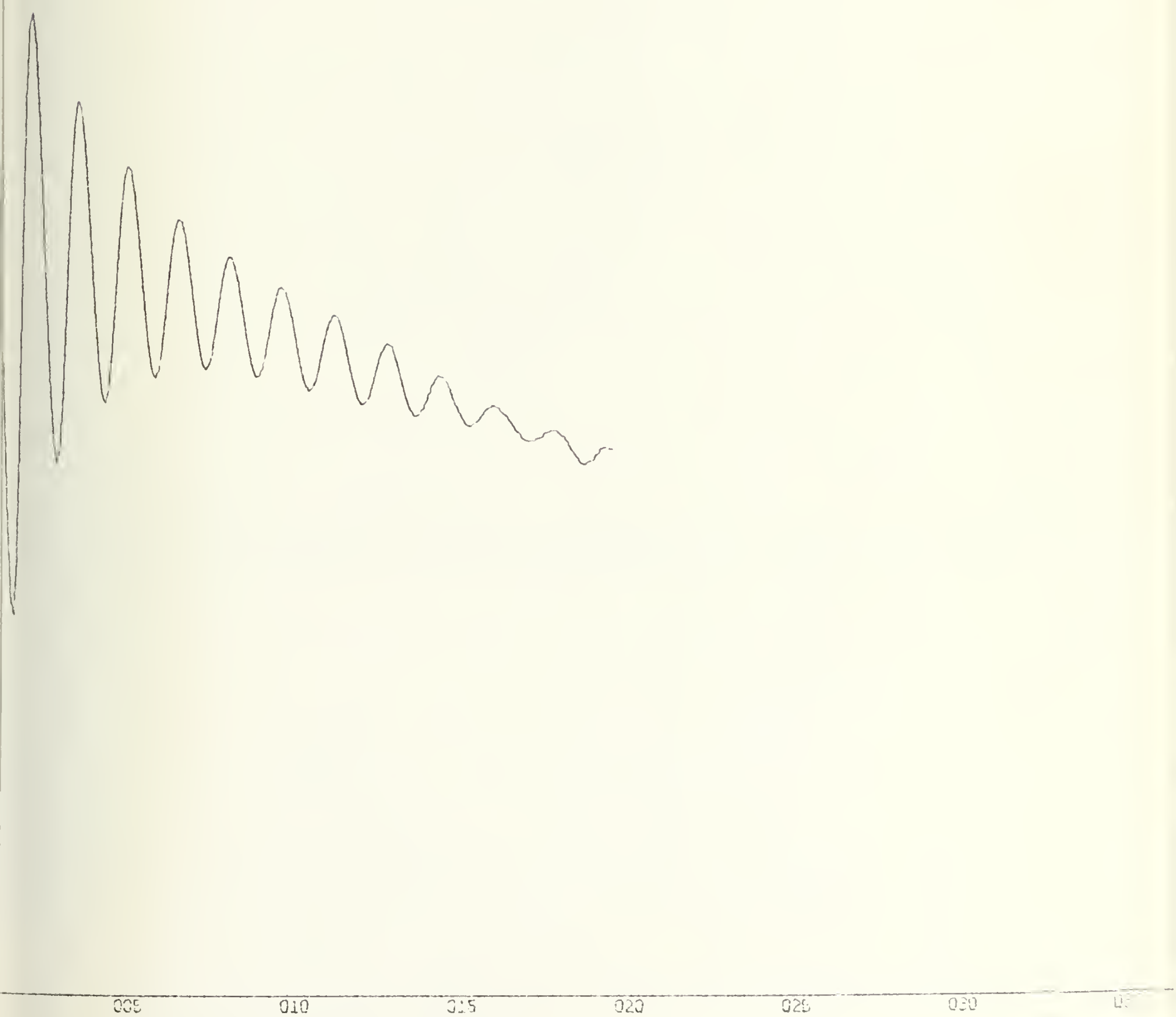
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 6
.OT IS PITCH ANGLE VERSUS TIME

PLOT 50



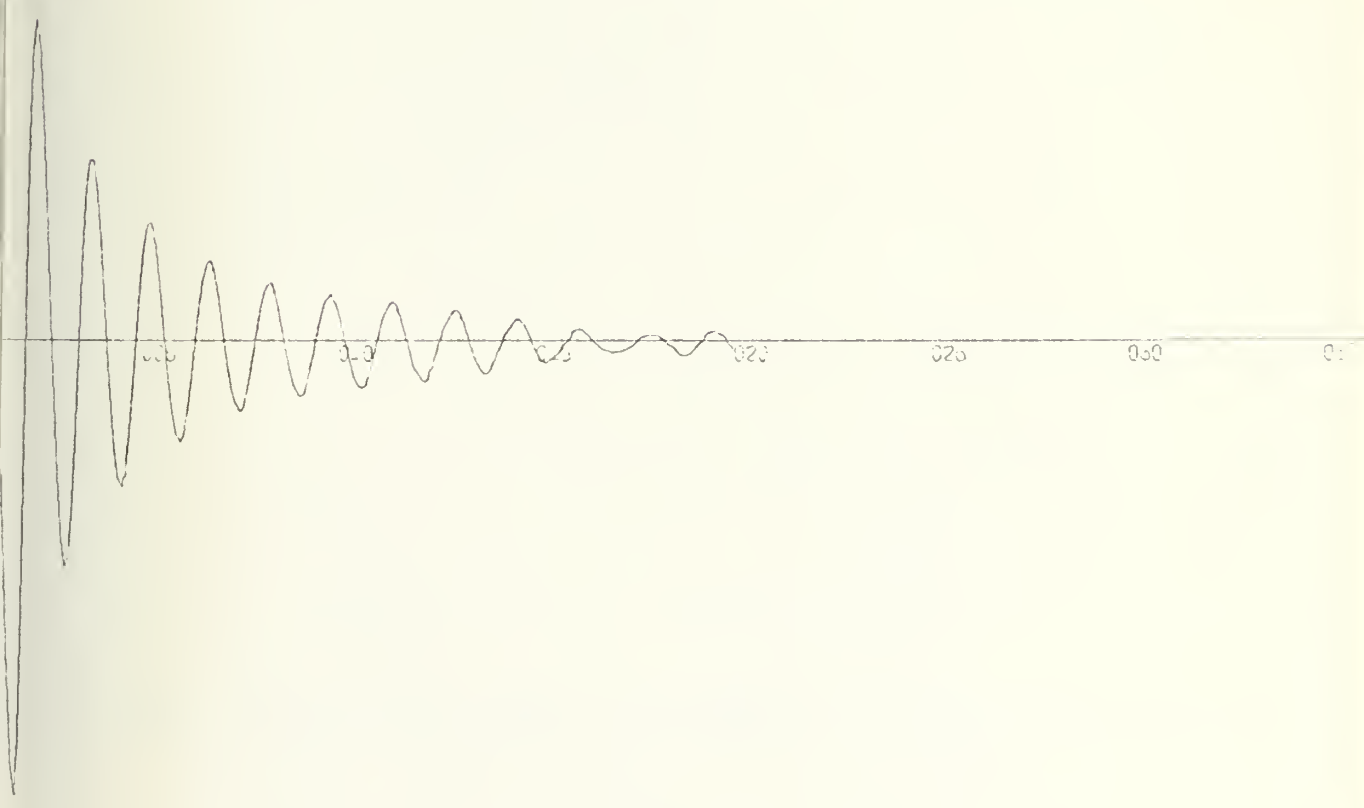
SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 6
LOT IS PITCH RATE VERSUS TIME

PLOT 51



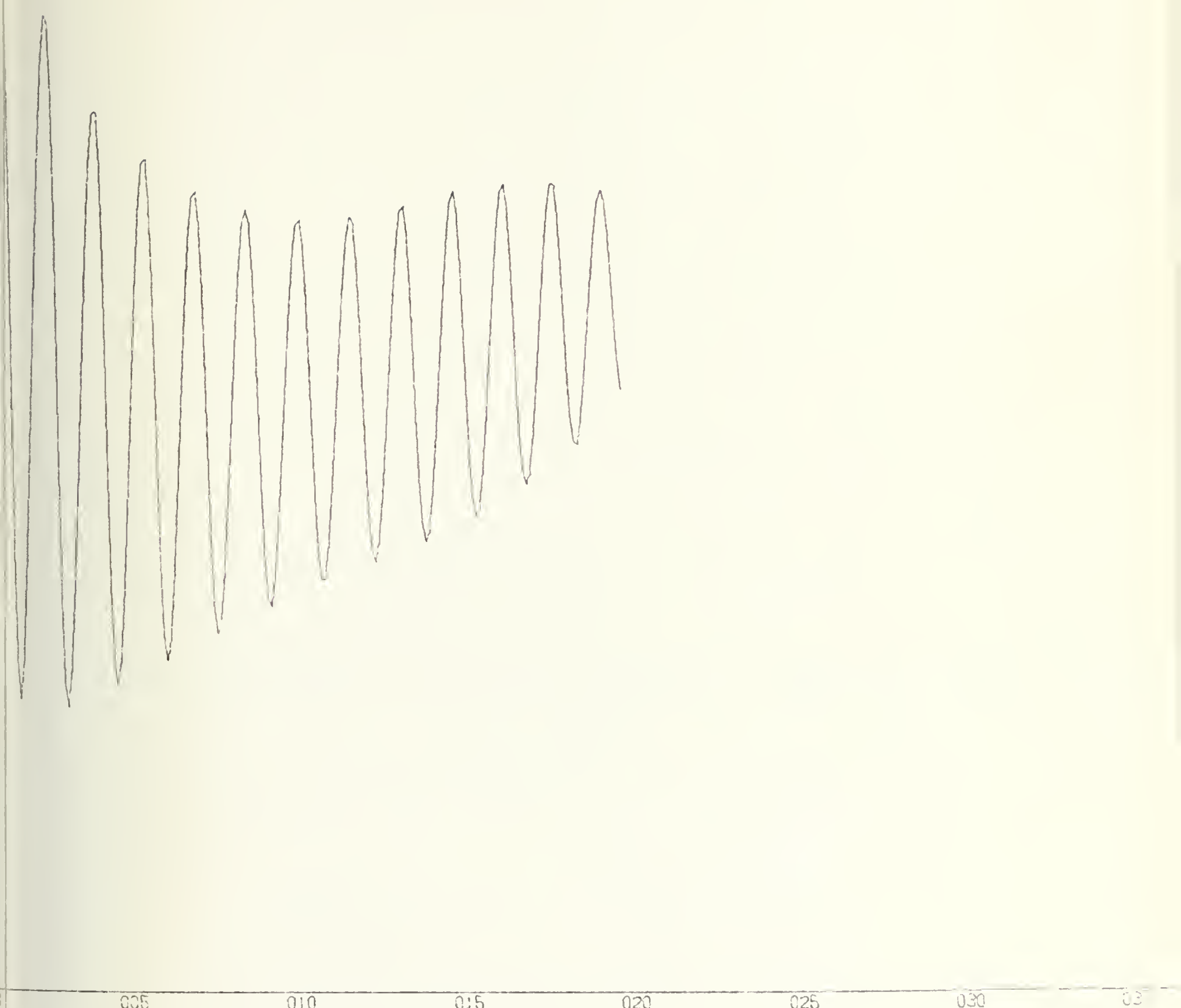
SCALE=5.00E+00 UNITS INCH. 153
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 6
LOT IS ROLL ANGLE VERSUS TIME

PLOT 52



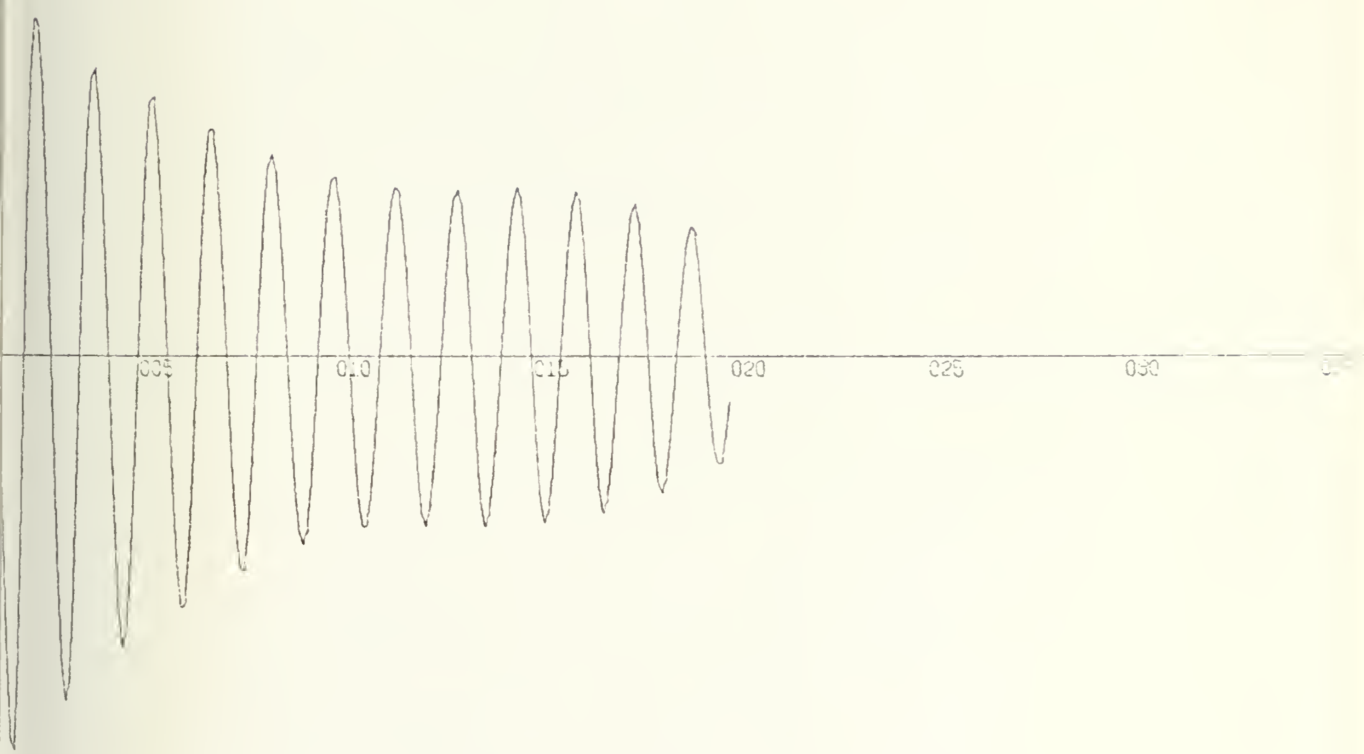
SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 6
LOT IS ROLL RATE VERSUS TIME

PLOT 53



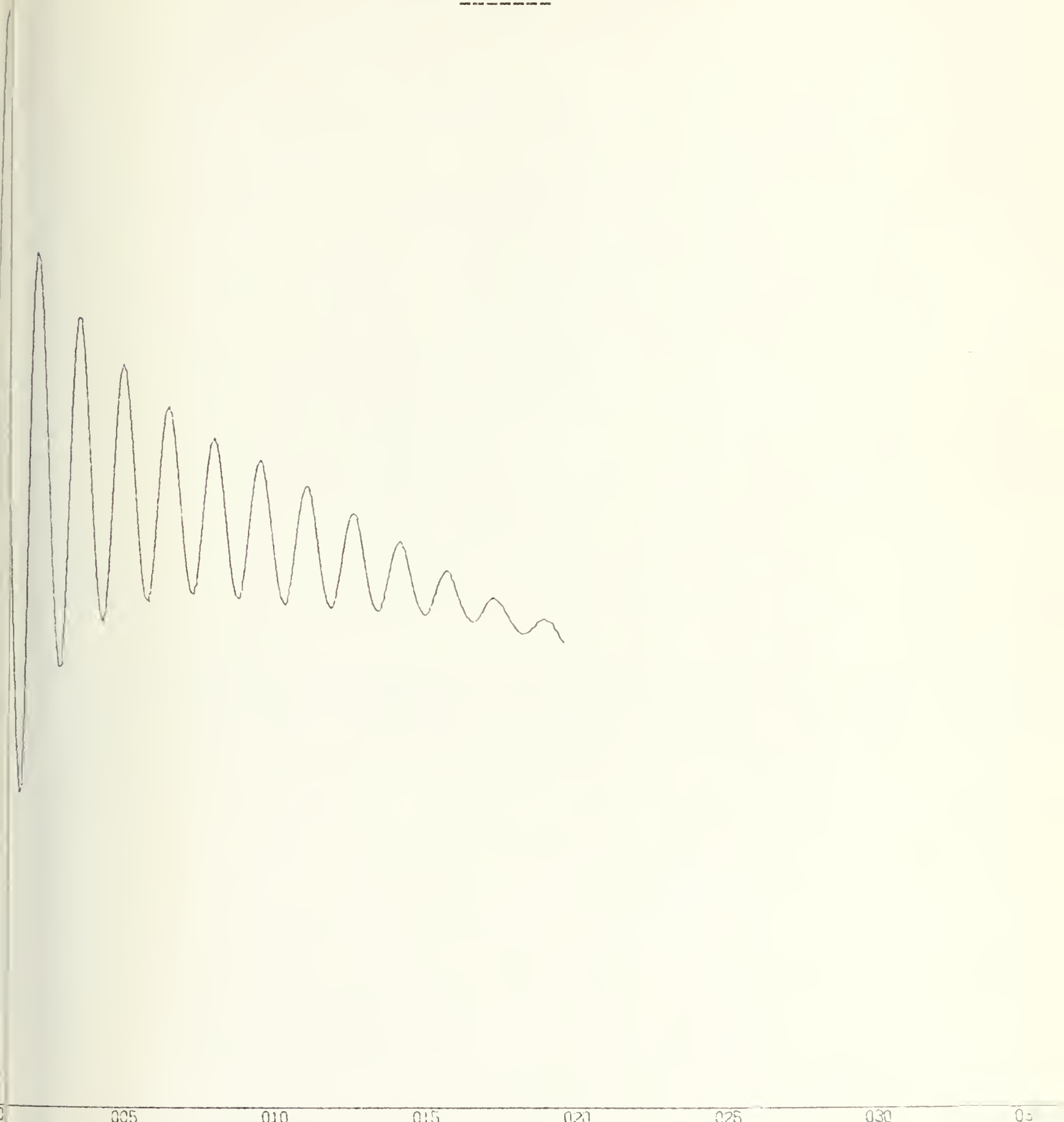
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 7
LOT IS PITCH ANGLE VERSUS TIME

PLOT 54



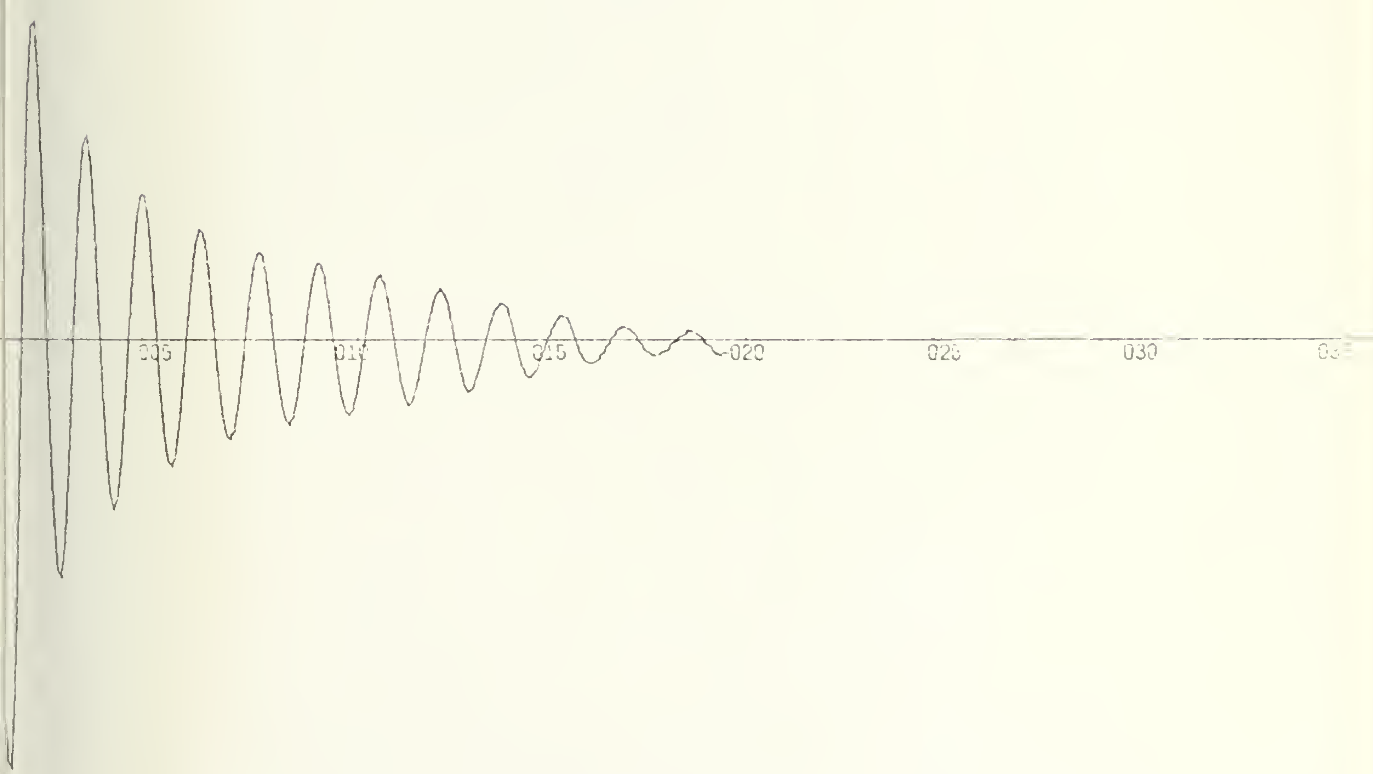
SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 7
LOT IS PITCH RATE VERSUS TIME

PLOT 55



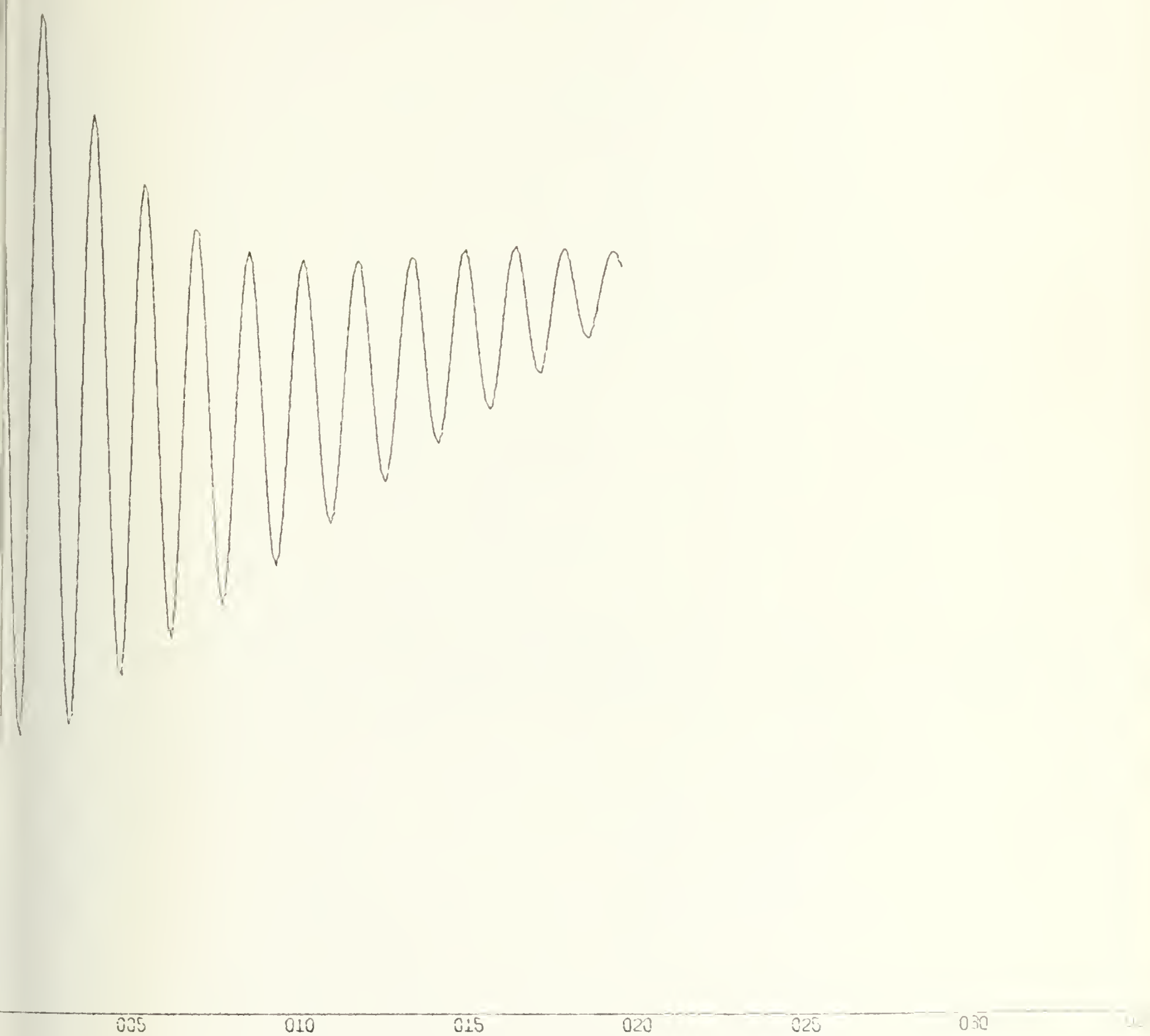
SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 7
LOT IS ROLL ANGLE VERSUS TIME

PLOT 56



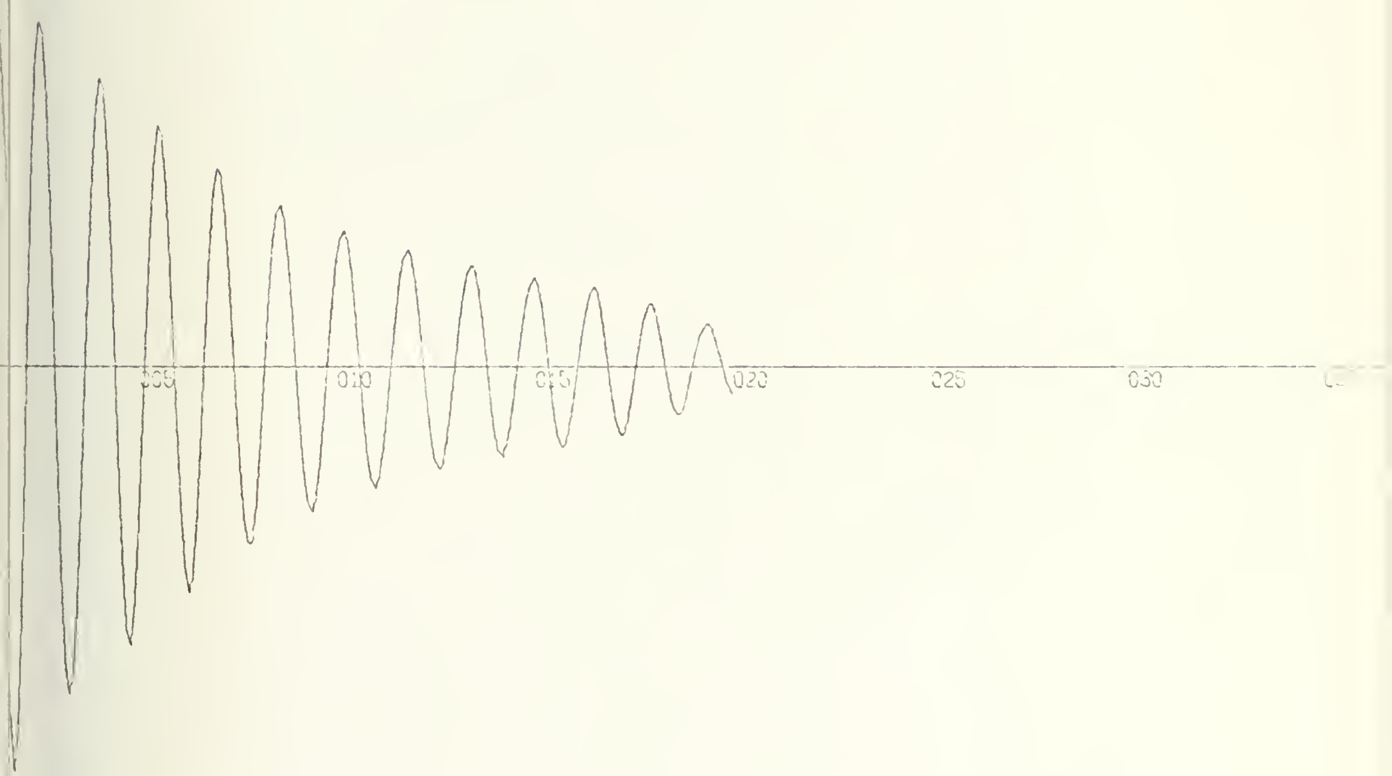
SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+00 UNITS INCH.
ØGRAM 3, TURN AT 20 KNØTS WITH R.D. 7
ØT IS RØLL RATE VERSUS TIME

PLOT 57



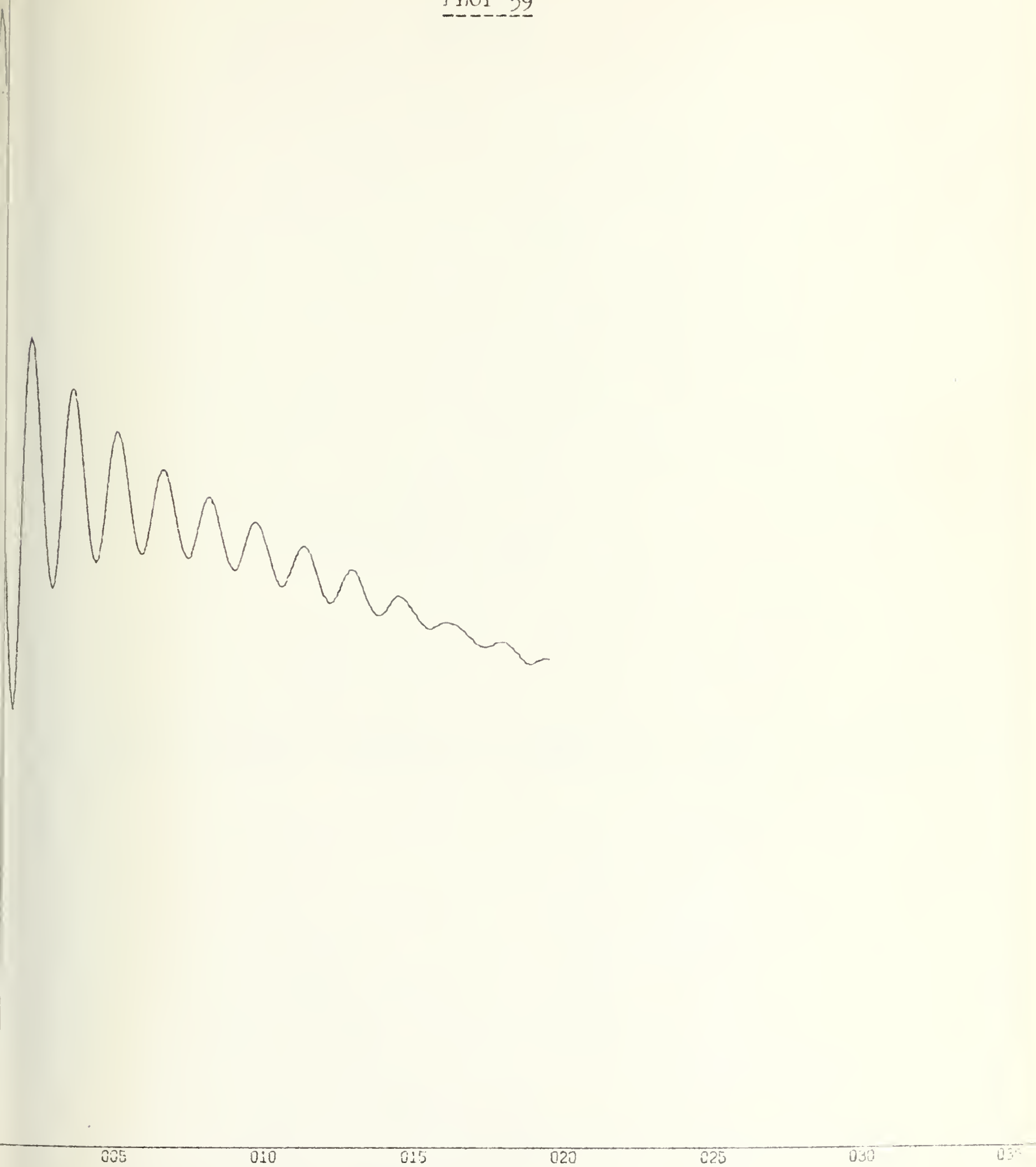
SCALE=5.00E+00 UNITS INCH.
SCALE=2.00E-01 UNITS INCH.
RØGRAM 3. TURN AT 20 KNØTS WITH R.D. 8
LØT IS PITCH ANGLE VERSUS TIME

PLOT 58



SCALE=5.00E+00 UNITS INCH.
SCALE=1.00E+00 UNITS INCH.
ØGRAM 3, TURN AT 20 KNØTS WITH R.D. 8
ØT IS PITCH RATE VERSUS TIME

PLOT 59



SCALE=5.00E+00 UNITS INCH.

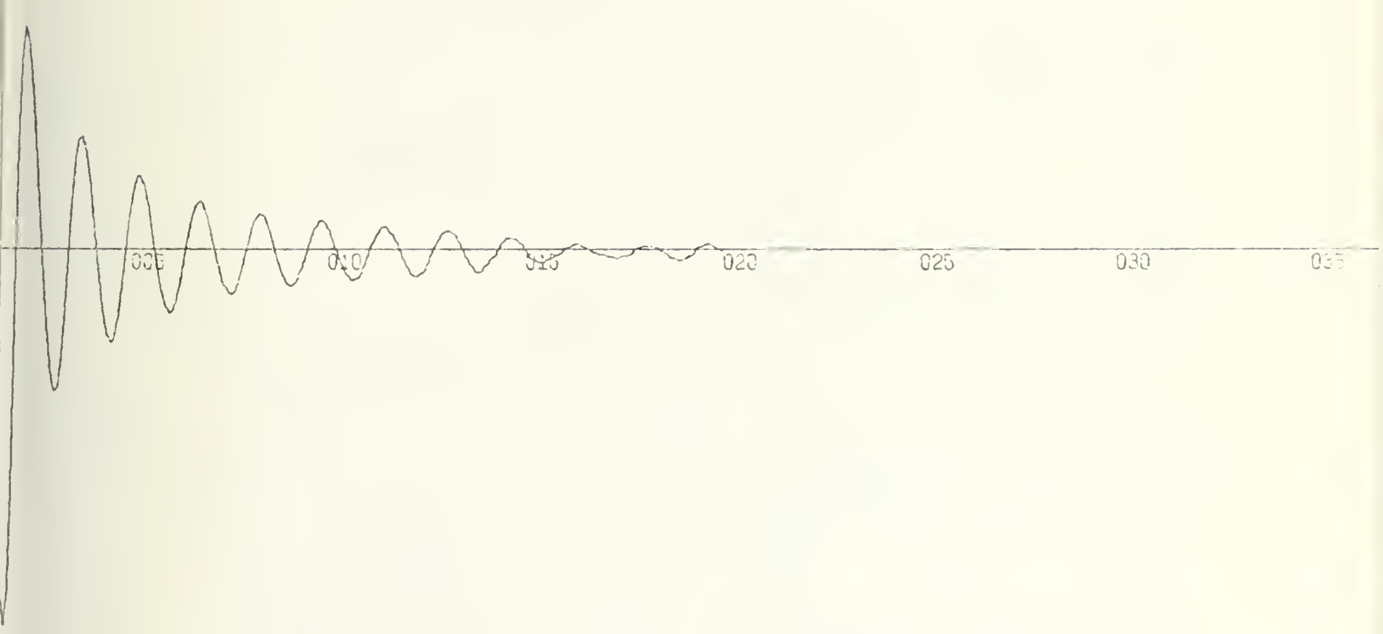
SCALE=1.00E+00 UNITS INCH.

ROGRAM 3, TURN AT 20 KNOTS WITH R.D. 8

LOT IS ROLL ANGLE VERSUS TIME

161

PLOT 60



SCALE=5.00E+00 UNITS INCH.
SCALE=5.00E+00 UNITS INCH.
ROGRAM 3. TURN AT 20 KNOTS WITH R.D. 8
LOT IS ROLL RATE VERSUS TIME

LISTING OF INPUT DECK

```
00101 0.0         20.0        0.01        0.1
00102
00103
1002
.0001       .0002       .00001      .0000001  .0001       .000001     .000000001.000000001
.0001       .0001
00104
    1    1
00105
00106 0.5         32.
00201 6050.0      10.05       2.54        2870.0      9320.0   10580.0   -2800.0
00301   11.0        11.0        5.0         5.0       24.7
00401   5.37        21.9         .7         1.28        .5
00501   3.97        1.875       3.37        0.90      1.875      1.0        4.06
00601   23.44       0.9         1.0         1.875     1.875      4.06     0.08
00602  1.1875
00701  20.0        10.0       17.2        10.0        20.0       10.4       1.915
00702   0.556
00801  -1.275       5.55      -0.604
00901  -1.125       5.55      -0.208       1.21        2.15       .68        .167
01000  20.0        10.0
01101
01201 20.0        0.45        6.06        24.84
01601 186.18                  0.01
01602 186.18                  0.01
01603 35.0
018
RIGHT RUDDER, 35.0 DEGREES, 20.0 KNOTS, CONSTANT THRUST
01901  2.0         8000.0  19.0         1.0
 -10.406    -5.203      0.0         5.203       10.406      15.609      18.211      20.812
 23.414     26.015      28.617      31.218      33.820      36.421      41.624      46.827
 52.030     57.233      62.436
 22.7       22.067      20.67       19.60       18.367      17.133      16.467      15.10
 12.20      10.00       7.80        6.40        5.20        4.33        2.60        .983
 -.020      -1.06       -2.03
01902  2.0         8000.0  19.0         1.0
 -10.406    -5.203      0.0         5.203       10.406      15.609      18.211      20.812
 23.414     26.015      28.617      31.218      33.820      36.421      41.624      46.827
 52.030     57.233      62.436
 22.7       22.067      20.67       19.60       18.367      17.133      16.467      15.10
 12.20      10.00       7.80        6.40        5.20        4.33        2.60        .983
 -.020      -1.06       -2.03
01903  1.0        8000.0   19.0         1.0
 -10.406    -5.203      0.0         5.203       10.406      15.609      18.211      20.812
 23.414     26.015      28.617      31.218      33.820      36.421      41.624      46.827
```

```
 52.030      57.233      62.436
 25.70       24.33       23.167      21.83       20.61       19.33       18.85       17.73
 16.40       12.60       10.367      8.033       6.331       5.073       3.035       1.60
  0.00       -1.06       -2.03
020
0000
021
0103040506070809
0112131423242526
022
0401
0104010901230124
TURN AT 20 KNOTS WITH R. D. 8
013
014
```

```
C
C      MAIN DECK
C
       INTEGER ON
       COMMON /AIR/ PINF,RHOINF,GAM
       COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IY
       COMMON /CONST/ PI,RAD,UO
       COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,
      ATIP(25),TIS(25)
       COMMON /EQNCO/ NEQS,TCL(20),JQQ
       COMMON /FPROP/ FXP,FYP,FZP,FKP,FMP,FNP
       COMMON / FROUDE / FN,FNCRIT
       COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT
       COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
       COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,
      -IRUD,IPROP,IAEROD,IRHS
       COMMON /ROLL/ PHIMAX,TROLL
       COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,
      ARCLB,RTC,RUDANG,TIR(25)
       COMMON / VALOLD / YOLD(20)
       COMMON /VARBLE/ VAL(40)
       COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,
      1              FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV
      2              ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR
       EQUIVALENCE                (VAL(2),U),(VAL(3),V),(VAL(4),W),
      1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),
      2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),
      3(VAL(24),PB)
       DIMENSION DUMMY(20)
C
       TC=1.0
       ON=1
       PI=4.*ATAN(1.)
       RAD=180./PI
       WRITE(6,100)
 100   FORMAT(1H1//35X,22H LISTING OF INPUT DECK  //)
 99    READ(44,101,END=104) DUMMY
 101   FORMAT(20A4)
 105   WRITE(6,102)DUMMY
       WRITE(5,101) DUMMY
 102   FORMAT(5X,20A4)
       GO TO 99
 104   REWIND 5
C
```

```
 11   CALL INCON(TIME)                                                  MAIN0450
C                                                                       MAIN0460
      IF (IMM.EQ.3)  GO TO 605                                          MAIN0470
      DO 10 J=1,20                                                      MAIN0480
 10   YOLD(J)=VAL(J+1)                                                  MAIN0490
      GO TO 2                                                           MAIN0500
  1   CONTINUE                                                          MAIN0510
      TOLD=TIME                                                         MAIN0520
      PBBAR=PBBAR*(1.-DELT/TC)+DELT*(PB-PINF)/TC                        MAIN0530
      IF ( NWAVE.LE.0 )  GO TO 13                                       MAIN0540
      ZBAR=(1.-DELT/TC)*ZBAR+DELT*Z/TC                                  MAIN0550
      PHIBAR=(1.-DELT/TC)*PHIBAR+DELT*PHI/TC                            MAIN0560
      THEBAR=(1.-DELT/TC)*THEBAR+DELT*THETA/TC                          MAIN0570
C                                                                       MAIN0580
      CALL WAVES(TIME)                                                  MAIN0590
 13   CALL SIDEWL                                                       MAIN0600
      CALL PROP                                                         MAIN0610
      CALL RUDDER                                                       MAIN0620
      CALL AEROD                                                        MAIN0630
      CALL INTGRL(TIME)                                                 MAIN0640
C                                                                       MAIN0650
      IF(TIME.GT.FTIME) GO TO 12                                        MAIN0660
      IF ( FN.GT.FNCRIT) GO TO 14                                       MAIN0670
      PRINT 505                                                         MAIN0680
      GO TO 12                                                          MAIN0690
 14   DELOLD=TIME-TOLD                                                  MAIN0700
      PSI=PSI+DELOLD*R                                                  MAIN0710
      X=X+DELOLD*(U*COS(PSI)-V*SIN(PSI))                                MAIN0720
      Y=Y+DELOLD*(U*SIN(PSI)+V*COS(PSI))                                MAIN0730
 15   IF (ABS(TIME-TPRINT) .LT. 1.E-6) GO TO 2                          MAIN0740
      GO TO 1                                                           MAIN0750
  2   CONTINUE                                                          MAIN0760
      IF(ITRAJ .EQ. 0) GOTO 16                                          MAIN0770
      DPHI=PHI*RAD                                                      MAIN0780
      DPSI=PSI*RAD                                                      MAIN0790
      DTHETA=THETA*RAD                                                  MAIN0800
      DP=P*RAD                                                          MAIN0810
      DQ=Q*RAD                                                          MAIN0820
      DR=R*RAD                                                          MAIN0830
      VEL=0.5925*U                                                      MAIN0840
      WRITE (6,500) TIME,VEL,V,W,DP,DQ,DR,Z,DPHI,DTHETA,X,Y,DPSI        MAIN0850
      BETS=(-V/U)*RAD                                                   MAIN0860
      DELRS=RUDANG*RAD                                                  MAIN0870
      WRITE(6,501) BETS,DELRS,FXP                                       MAIN0880
 16   CONTINUE                                                          MAIN0890
      IMMTAG = (IMM+1)/2                                                MAIN0900
      IF ( IMMTAG .EQ. 1  .AND. TIME.GE.BTIME-1.E-8 )  IMT = 1          MAIN0910
      TPRINT=TPRINT+DELPNT                                              MAIN0920
```

```
      ON=1                                                              MAIN0930
      GO TO 1                                                           MAIN0940
C                                                                       MAIN0950
 12   CALL COLFIL                                                       MAIN0960
C                                                                       MAIN0970
      IF (IMM.LT.1)  GO TO 11                                           MAIN0980
      IF (IMM.NE.1)  GO TO 605                                          MAIN0990
      END FILE IBMFIL                                                   MAIN1000
      GO TO 11                                                          MAIN1010
C                                                                       MAIN1020
 605  CALL SAM                                                          MAIN1030
C                                                                       MAIN1040
      GO TO 11                                                          MAIN1050
C                                                                       MAIN1060
 500 FORMAT(//10X,13HTIME (SEC) =  F6.2//10X,33HTRANSLATIONAL VELS (KTSMAIN1070
    1)/(FT/SEC) /10X,2HU= F6.2,5X,2HV= F6.2,5X,2HW= F6.3//10X,31HROTATIMAIN1080
    2ONAL VELOCITIES (DEG/SEC) /10X,2HP= F6.2,5X,2HQ= F6.2,5X,2HR= F6.2MAIN1090
    3//10X,30HDISPLACEMENTS (FT AND DEGREES) /10X,2HZ= F7.3,5X,4HPHI=  MAIN1100
    4F6.2,3X,6HTHETA= F6.2//10X,27HTRAJECTORY (FT AND DEGREES) /10X,   MAIN1110
    52HX= F8.2,4X,2HY= F8.2,4X,4HPSI= F8.2)                            MAIN1120
 501 FORMAT(1H0,9X,23HSIDESLIP ANGLE (DEG) =    F8.2,10X,21HRUDDER ANGLEMAIN1130
    1 (DEG) =  F8.3,10X,15HTHRUST (LBS) =   F12.1)                     MAIN1140
 505 FORMAT(///25X,28HCRAFT SPEED BELOW HUMP SPEED )                    MAIN1150
C                                                                       MAIN1160
      END                                                               MAIN1170


C                                                                       BLDA0010
      BLOCK DATA                                                        BLDA0020
C                                                                       BLDA0030
      COMMON /AIR/ Z1(3)                                                BLDA0040
C    IN MAIN, INCON, SIDEWL, RHS, BOWSL, STNSL, FAN                     BLDA0050
      COMMON /BMCO/ Z2(25)                                              BLDA0060
C    IN MAIN, INCON, WAVES, SIDEWL, RHS, INTGRL                         BLDA0070
      COMMON /COLUMN / Z3(2)                                            BLDA0080
C    IN INCON, RHS, COLFIL                                              BLDA0090
      COMMON /CONST/ Z4(3)                                              BLDA0100
C    IN MAIN, INCON, WAVES, SIDEWL, PROP, RUDDER, RHS, BOWSL, STNSL     BLDA0110
      COMMON /CNTRL/ Z5(10)                                             BLDA0120
C    IN INCON, RHS                                                      BLDA0130
      COMMON /ENGINE/ Z6(107)                                           BLDA0140
C    IN MAIN, INCON, PROP, RHS                                          BLDA0150
      COMMON /EQNCO/ Z7(22)                                             BLDA0160
C    IN MAIN, INCON, INTGRL, COLFIL                                     BLDA0170
      COMMON /FAERO/ Z8(6)                                              BLDA0180
C    IN AEROD, RHS                                                      BLDA0190
      COMMON /FAIR/ Z9(2)                                               BLDA0200
C    IN INCON, AEROD                                                    BLDA0210
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      COMMON /FANMAP/ Z10(262)                                          BLDA0220
C     IN INCON, RHS, FAN                                                BLDA0230
      COMMON /FORBS/ Z11(7)                                             BLDA0240
C     IN RHS, BOWSL                                                     BLDA0250
      COMMON /FORSS/Z12(8)                                              BLDA0260
C     IN RHS, STNSL                                                     BLDA0270
      COMMON /FPROP/ Z13(6)                                             BLDA0280
C     IN MAIN, PROP, RHS                                                BLDA0290
      COMMON /FROUDE/ Z14(2)                                            BLDA0300
C     IN MAIN, INCON, RHS                                               BLDA0310
      COMMON /FRUD/ Z15(6)                                              BLDA0320
C     IN RUDDER, RHS                                                    BLDA0330
      COMMON /GBOW/ Z16(1)                                              BLDA0340
C     IN INCON, RHS                                                     BLDA0350
      COMMON /GEOM/ Z17(138)                                            BLDA0360
C     IN INCON, WAVES, SIDEWL, RHS, BOWSL, STNSL                        BLDA0370
      COMMON /GEOMBS/ Z18(62)                                           BLDA0380
C     IN WAVES, RHS, BOWSL                                              BLDA0390
      COMMON /GEOMSS/ Z19(62)                                           BLDA0400
C     IN WAVES, RHS, STNSL                                              BLDA0410
      COMMON /GEOMSW/ Z20(11)                                           BLDA0420
C     IN INCON, SIDEWL                                                  BLDA0430
      COMMON /KSWTCH/ Z21(1)                                            BLDA0440
C     IN SIDEWL, RHS, STNSL, INTGRL                                     BLDA0450
      COMMON /LEAKER/ Z22(4)                                            BLDA0460
C     IN INCON, BOWSL, STNSL                                            BLDA0470
      COMMON /MASSES/ Z23(817)                                          BLDA0480
C     IN INCON, WAVES, SIDEWL, RUDDER, RHS, BOWSL, STNSL, INTGRL        BLDA0490
      COMMON /MATRIX/ Z24(36)                                           BLDA0500
C     IN INCON, RHS                                                     BLDA0510
      COMMON /MSIDW/ Z25(55)                                            BLDA0520
C     IN SIDEWL, RHS                                                    BLDA0530
      COMMON /MWAVE/ Z26(12)                                            BLDA0540
C     IN WAVES, RHS                                                     BLDA0550
      COMMON /OPTION/ Z27(4)                                            BLDA0560
C     IN INCON, RHS                                                     BLDA0570
      COMMON /PLENUM/ Z28(4)                                            BLDA0580
C     IN INCON, WAVES, SIDEWL, RHS                                      BLDA0590
      COMMON /PRIME/ Z29(5)                                             BLDA0600
C     IN MAIN, INCON, SIDEWL, RHS, INTGRL                               BLDA0610
      COMMON /PRTINT/ Z30(12)                                           BLDA0620
C     IN MAIN, INCON, WAVES, SIDEWL, PROP, RUDDER, AEROD, RHS, BOWSL,   BLDA0630
C       STNSL, FAN, INTGRL                                              BLDA0640
      COMMON /PWAVE/ Z31(2)                                             BLDA0650
C     IN INCON, RHS                                                     BLDA0660
      COMMON /RISER/ Z32(1)                                             BLDA0670
C     IN INCON, WAVES                                                   BLDA0680
      COMMON /ROLL/ Z33(2)                                              BLDA0690
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C     IN MAIN, INCON                                                    BLDA0700
        COMMON /RUDDR/ Z34(62)                                          BLDA0710
C     IN MAIN, INCON, PROP, RUDDER, RHS                                 BLDA0720
        COMMON /SIDE/ Z35(22)                                           BLDA0730
C     IN INCON, WAVES, SIDEWL, RHS                                      BLDA0740
        COMMON /SOFTBS/ Z36(20)                                         BLDA0750
C     IN INCON, RHS, BOWSL, FAN                                         BLDA0760
        COMMON /SOFTSS/ Z37(19)                                         BLDA0770
C     IN INCON, RHS, STNSL, FAN                                         BLDA0780
        COMMON /STABLE/ Z38(5)                                          BLDA0790
C     IN INCON, INTGRL                                                  BLDA0800
        COMMON /STSLR/ Z39(2)                                           BLDA0810
C     IN INCON, STNSL                                                   BLDA0820
        COMMON /VALOLD/ Z40(20)                                         BLDA0830
C.    IN MAIN, INCON, RHS, STNSL, INTGRAL                               BLDA0840
        COMMON /VARBLE/ Z41(40)                                         BLDA0850
C     IN MAIN, INCON, WAVES, SIDEWL, PROP, RUDDER, AEROD, RHS, BOWSL,   BLDA0860
C       STNSL, FAN, INTGRL                                              BLDA0870
        COMMON /WAVE/ Z42(80)                                           BLDA0880
C     IN MAIN, INCON, WAVES, SIDEWL, RHS, BOWSL, STNSL                  BLDA0890
        COMMON /WAVEF / Z43(40)                                         BLDA0900
C     IN INCON                                                          BLDA0910
        COMMON /SLOPE/Z44(5)                                            BLDA0920
C     IN INCON, RHS, BOWSL                                              BLDA0930
        COMMON /PROMOD/ Z45(7)                                          BLDA0940
C     IN MAIN AND ALL SUBROUTINES                                       BLDA0950
C                                                                       BLDA0960
        DATA Z1/3*0.0/                                                  BLDA0970
        DATA Z2/25*0.0/                                                 BLDA0980
        DATA Z3/2*0.0/                                                  BLDA0990
        DATA Z4/3*0.0/                                                  BLDA1000
        DATA Z5/10*0.0/                                                 BLDA1010
        DATA Z6/107*0.0/                                                BLDA1020
        DATA Z7/21*0.0/                                                 BLDA1030
        DATA Z8/6*0.0/                                                  BLDA1040
        DATA Z9/2*0.0/                                                  BLDA1050
        DATA Z10/262*0.0/                                               BLDA1060
        DATA Z11/7*0.0/                                                 BLDA1070
        DATA Z12/8*0.0/                                                 BLDA1080
        DATA Z13/6*0.0/                                                 BLDA1090
        DATA Z14/2*0.0/                                                 BLDA1100
        DATA Z15/6*0.0/                                                 BLDA1110
        DATA Z16/0.0/                                                   BLDA1120
        DATA Z17/138*0.0/                                               BLDA1130
        DATA Z18/62*0.0/                                                BLDA1140
        DATA Z19/62*0.0/                                                BLDA1150
        DATA Z20/11*0.0/                                                BLDA1160
        DATA Z21/0.0/                                                   BLDA1170
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      DATA Z22/4*0.0/                                                   BLDA1180
      DATA Z23/817*0.0/                                                 BLDA1190
      DATA Z24/36*0.0/                                                  BLDA1200
      DATA Z25/55*0.0/                                                  BLDA1210
      DATA Z26/12*0.0/                                                  BLDA1220
      DATA Z27/4*0.0/                                                   BLDA1230
      DATA Z28/4*0.0/                                                   BLDA1240
      DATA Z29/5*0.0/                                                   BLDA1250
      DATA Z30/12*0.0/                                                  BLDA1260
      DATA Z31/2*0.0/                                                   BLDA1270
      DATA Z32/0.0/                                                     BLDA1280
      DATA Z33/2*0.0/                                                   BLDA1290
      DATA Z34/62*0.0/                                                  BLDA1300
      DATA Z35/22*0.0/                                                  BLDA1310
      DATA Z36/20*0.0/                                                  BLDA1320
      DATA Z37/19*0.0/                                                  BLDA1330
      DATA Z38/5*0.0/                                                   BLDA1340
      DATA Z39/2*0.0/                                                   BLDA1350
      DATA Z40/20*0.0/                                                  BLDA1360
      DATA Z41/40*0.0/                                                  BLDA1370
      DATA Z42/80*0.0/                                                  BLDA1380
      DATA Z43/40*0.0/                                                  BLDA1390
      DATA Z44/5*0.0/                                                   BLDA1400
      DATA Z45/7*0.0/                                                   BLDA1410
C                                                                       BLDA1420
      END                                                               BLDA1430

C                                                                       INCN0010
      SUBROUTINE INCON (TIME)                                           INCN0020
C                                                                       INCN0030
      REAL*8 TICRD                                                      INCN0040
      INTEGER ON                                                        INCN0050
      COMMON /AIR/ PINF,RHOINF,GAM                                      INCN0060
      COMMON/AXIS/NXYS(26)                                              INCN0070
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYINCN0080
      COMMON /COLUMN/ IVERT,ILATRL                                      INCN0090
      COMMON /CONST/ PI,RAD,UO                                          INCN0100
      COMMON /CNTRL/CONTW,CONTQ,CONTTH,QMULT,LOUVER,ACONTZ,ACONTW,ZEQUILINCN0110
     1 ,THEQL,ACBASE                                                    INCN0120
      COMMON /CURVE/NCURV(10)                                           INCN0130
      COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,     INCN0140
     ATIP(25),TIS(25)                                                   INCN0150
      COMMON /EQNCO/ NEQS,TOL(20),JQQ                                   INCN0160
      COMMON /FAIR/ RHOA,XLAERO                                         INCN0170
      COMMON /FANMAP/QIN,QBFAN(25),QMFAN(25),QSFAN(25),ENBFAN,ENMFAN,   INCN0180
     1 ENSFAN,BRPM,EMRPM,SRPM,NPTSB,NPTSM,NPTSS                         INCN0190
     2 ,PBFAN(25),PMFAN(25),PSFAN(25),TMEB(25),DELB(25),NB,TMES(25),    INCN0200
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     3DETS(25),NS                                                       INCN0210
      COMMON / FROUDE / FN,FNCRIT                                       INCN0220
      COMMON/GBOW/ XBOW                                                 INCN0230
      COMMON /GEOM/     WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM    INCN0240
     1,DELS(4,10),XCP,ZCP                                               INCN0250
      COMMON /GEOMSW/ XAVG(10),DS                                       INCN0260
      COMMON/GRAF/NGRAF,NDRW                                            INCN0270
      COMMON /HEADG/TICRD(6)                                            INCN0280
      COMMON /PWAVE/ FNCON,PWVCON                                       INCN0290
      COMMON/LEAKER/ALEAK,BLEAK,CFSS,CFBS                               INCN0300
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  INCN0310
     -                AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO       INCN0320
      COMMON /MATRIX/ A(6,6)                                            INCN0330
      COMMON /OPTION/ I3DOF,ISRGE,ITRIM,IDIA                            INCN0340
      COMMON /PLENUM/XLBW,XBBW,ABW,BUBHGT                               INCN0350
      COMMON/ PLVCQQ/NVI,NVD,NLI,NLD                                    INCN0360
      COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT                     INCN0370
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  INCN0380
     -IRUD,IPROP,IAEROD,IRHS                                            INCN0390
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7  INCN0400
      COMMON /ROLL/ PHIMAX,TROLL                                        INCN0410
      COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,  INCN0420
     ARCLB,RTC,RUDANG,TIR(25)                                           INCN0430
      COMMON /RISER/ AMPTC                                              INCN0440
      COMMON/SOFTBS/XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAVG INCN0450
     1B(10),CENCAB                                                      INCN0460
      COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS           INCN0470
     1 ,ELMAXS,YAVGS(10)                                                INCN0480
      COMMON /SIDE/FXSW,FYSW,FZSW,FKSW,FMSW,FNSW,ALSW,YSW,XLSW,CFSW,CDSWINCN0490
     1,VAREA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY, VZ  ,AVBMSW,DELX,VTC     INCN0500
      COMMON/SLOPE/WATSLP,XPWV,XLXPWV,PWVHT,XPWVXS                      INCN0510
      COMMON /STABLE/ S(4),ISTAB                                        INCN0520
      COMMON /STSLR/ CPHI,CPHID                                         INCN0530
      COMMON /SUM/ ISUM1(8),ISUM2(8)                                    INCN0540
      COMMON / VALOLD / YOLD(20)                                        INCN0550
      COMMON /VARBLE/ VAL(40)                                           INCN0560
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVCLW,NWAVE,BETA,        INCN0570
     1              FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                 INCN0580
     2              ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR          INCN0590
      COMMON /WAVEF/WAVLEN(10),OMEGAE(10),WAVSLP(10),ENCPER(10)         INCN0600
      COMMON /WAVTAB/ NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,  INCN0610
     1          AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),        INCN0620
     2          AC5(20,5,7),AC6(20,5,7),AC7(20,5,7)                     INCN0630
     3          ,AC0(20,5,7),AC00(20,5,7),AC8(20,5,7),                  INCN0640
     4          AS1(20,5,7),AS2(20,5,7),AS3(20,5,7),AS4(20,5,7),        INCN0650
     5          AS5(20,5,7),AS6(20,5,7),AS7(20,5,7)                     INCN0660
     6          ,AS0(20,5,7),AS00(20,5,7),AS8(20,5,7)                   INCN0670
     7          ,BB(36),XREF,RX                                         INCN0680
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```
      DIMENSION ZZZ(14050)
      EQUIVALENCE (ZZZ,NAL)
      EQUIVALENCE            (VAL(2),U),(VAL(3),V),(VAL(4),W),
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),
     3(VAL(24),PB)
      DIMENSION TEMP(7),XMO(10)
      DIMENSION TITLC(20)
      DATA BEAM,BETAD,DELO,DELPI,DLRDO,DSO,ISYS,RMAXO,RONO,RRATO,RREVO,
     1 THETO,THSSI,TPRINO,UO,VXO,VZO,XBSI,XCPO,XLTOT,XPO,XRO,XSSI,YPO,
     2 ZPO,ZRO,ZSSI/ 6*0.0,0,20*0.0/
C
C     INITIAL CONDITIONS WITH WATSLP
C
      DO 9 I=1,8
      ISUM1(I)=0
    9 ISUM2(I)=0
      PINF=2116.
      RHOINF=.002378
      GAM=1.4
      GO TO 10
 2200 READ(5,3000) NGRAF,NDRW
 3000 FORMAT(2I2)
      READ(5,3001) NXYS
 3001 FORMAT(26I2)
      READ(5,3002) TICRD
 3002 FORMAT(6A8)
10    READ(5,99) ISYSL,IOPT,(TEMP(I),I=1,7)
      IF( ISYSL .EQ. ISYS .AND. ISYSL.EQ. 13) GOTO 70
      ISYS=ISYSL
      IF((ISYS.LE.0).OR.(ISYS.GT.22)) GO TO 70
      GOTO(100,200,300,400,500,600,700,800,900,1000,1100,1200,1300,
     11400,1500,1600,1700,1800,1900,2000,2100,2200),ISYS
C
C     PROGRAM CONTROL PARAMETERS
C
100   CONTINUE
      GOTO (101,102,103,104,105,106),IOPT
 101  CONTINUE
      STIME=TEMP(1)
      FTIME=TEMP(2)
      DELO=TEMP(3)
      DELPNT=TEMP(4)
      TPRINO=TEMP(5)
      IF (TPRINO.LT.STIME+DELPNT)  TPRINO = STIME+DELPNT
      IF (DELO.GT.DELPNT) DELO=DELPNT
      IF (DELO.EQ.0.0) GO TO 140
      GOTO 10
```

```
 2000 READ(5,3003) NCURV                                                INCN1170
 3003 FORMAT(10I1)                                                      INCN1180
      GO TO 10                                                          INCN1190
 2100 READ(5,2210) ISUM1                                                INCN1200
      READ(5,2210)ISUM2                                                 INCN1210
 2210 FORMAT(8I2)                                                       INCN1220
      GO TO 10                                                          INCN1230
102   READ (5,191) IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,IRUD,  INCN1240
     1 IPROP,IAEROD,IRHS                                                INCN1250
      GOTO 10                                                           INCN1260
103   READ (5,175) NEQS,JQQ,(TOL(J),J=1,NEQS)                           INCN1270
      GOTO 10                                                           INCN1280
 104  READ(5,191) IVERT,ILATRL,NVD,NVI,NLD,NLI                          INCN1290
      GO TO 10                                                          INCN1300
 105  CONTINUE                                                          INCN1310
      I3DOF=TEMP(1)                                                     INCN1320
      ISRGE=TEMP(2)                                                     INCN1330
      ITRIM=TEMP(3)                                                     INCN1340
      IDIA=TEMP(4)                                                      INCN1350
      GO TO 10                                                          INCN1360
  106 CONTINUE                                                          INCN1370
      PROMO1=TEMP(1)                                                    INCN1380
      PROMO2=TEMP(2)                                                    INCN1390
      PROMO3=TEMP(3)                                                    INCN1400
      PROMO4=TEMP(4)                                                    INCN1410
      PROMO5=TEMP(5)                                                    INCN1420
      PROMO6=TEMP(6)                                                    INCN1430
      PROMO7=TEMP(7)                                                    INCN1440
      GO TO 10                                                          INCN1450
  140 WRITE(6,195)                                                      INCN1460
      STOP                                                              INCN1470
C                                                                       INCN1480
C     MASS DISTRIBUTION                                                 INCN1490
C                                                                       INCN1500
  200 G=32.17                                                           INCN1510
      RHO=1.99                                                          INCN1520
      HRHO=RHO/2.                                                       INCN1530
      GO TO (210,220,230), ICPT                                         INCN1540
  210 IMM = 0                                                           INCN1550
      WEIGHT = TEMP(1)                                                  INCN1560
      AM = WEIGHT/G                                                     INCN1570
      XS = TEMP(2)                                                      INCN1580
      ZS = TEMP(3)                                                      INCN1590
      AIXX = TEMP(4)                                                    INCN1600
      AIYY = TEMP(5)                                                    INCN1610
      AIZZ = TEMP(6)                                                    INCN1620
      AIXZ = TEMP(7)                                                    INCN1630
C                                                                       INCN1640
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C       INERTIA MATRIX OPERATIONS                                               INCN1650
C                                                                               INCN1660
  212 DC 211 I=1,6                                                              INCN1670
      DO 211 N=1,6                                                              INCN1680
  211 A(I,N) = 0.0                                                              INCN1690
      DC 213 N=1,3                                                              INCN1700
  213 A(N,N)=AM                                                                 INCN1710
      A(4,4)=AIXX                                                               INCN1720
      A(5,5)=AIYY                                                               INCN1730
      A(6,6)=AIZZ                                                               INCN1740
      A(4,6)=-AIXZ                                                              INCN1750
      A(6,4)=-AIXZ                                                              INCN1760
      AIMAX=AMAX1(AM,AIXX,AIYY,AIZZ,ABS(AIXZ))                                  INCN1770
      DC 214 I=1,6                                                              INCN1780
      DO 214 J=1,6                                                              INCN1790
  214 A(I,J)=A(I,J)/AIMAX                                                       INCN1800
C                                                                               INCN1810
      CALL DMINV (A,6,D)                                                        INCN1820
C                                                                               INCN1830
      DC 215 I=1,6                                                              INCN1840
      DO 215 J=1,6                                                              INCN1850
  215 A(I,J)=A(I,J)/AIMAX                                                       INCN1860
      IF (D.NE.0.0) GO TO 10                                                    INCN1870
      WRITE (6,216)                                                             INCN1880
      STOP                                                                      INCN1890
C                                                                               INCN1900
C     READ WEIGHT DISTRIBUTION - ASSUME TRANSVERSE (PORT/STBD) SYMMETRY         INCN1910
C        X INPUT DIST. FWD. OF (SIDEWALL) TRANSOM                               INCN1920
C        Y INPUT DIST. TO STARBOARD                                             INCN1930
C        Z INPUT DIST. UP FROM KEEL-LINE                                        INCN1940
C                                                                               INCN1950
  220 I = 1                                                                     INCN1960
  222 READ (5,192) AMI(I),XI(I),YI(I),ZI(I)                                     INCN1970
      IF (AMI(I).LT.0.0)  GO TO 224                                             INCN1980
      I = I+1                                                                   INCN1990
      IF ( I.GT.201 )  GO TO 70                                                 INCN2000
      GO TO 222                                                                 INCN2010
  224 NMASS = I-1                                                               INCN2020
      SUM = 0.0                                                                 INCN2030
      SUX = 0.0                                                                 INCN2040
      SUZ = 0.0                                                                 INCN2050
      DO 225 I=1,NMASS                                                          INCN2060
      AMI(I) = AMI(I)/G                                                         INCN2070
      SUM = SUM+AMI(I)                                                          INCN2080
      SUX = SUX+AMI(I)*XI(I)                                                    INCN2090
  225 SUZ = SUZ+AMI(I)*ZI(I)                                                    INCN2100
      AM = SUM*2.0                                                              INCN2110
      WEIGHT = AM*G                                                             INCN2120
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```
      ZS  = SUZ/SUM
      XS  = SUX/SUM
      SUM = 0.0
      SUX = 0.0
      SUY = 0.0
      SUZ = 0.0
      DO 226 I=1,NMASS
      XI(I) = XI(I)-XS
      ZI(I) = -ZI(I)+ZS
      AMK = AMI(I)*2.0
      SUX = SUX+AMK*XI(I)*XI(I)
      SUY = SUY+AMK*YI(I)*YI(I)
      SUZ = SUZ+AMK*ZI(I)*ZI(I)
  226 SUM = SUM+AMK*XI(I)*ZI(I)
      AIXX = SUY+SUZ
      AIYY = SUX+SUZ
      AIZZ = SUX+SUY
      AIXZ = SUM
      GO TO 212
  230 GO TO 10
C
C     XX AND YY TABLES
C
500   CONTINUE
      NSTA(1) = TEMP(1)
      NSTA(2) = TEMP(2)
      NSTA(3) = TEMP(3)
      NSTA(4) = TEMP(4)
      XLTOT=TEMP(5)
      GOTO 10
C
C     SIDEWALL (INCLUDING APPENDAGES)
C
400   CONTINUE
      GOTO (401,402),IOPT
401   YSW=TEMP(1)
      XLSW=TEMP(2)
      CFSW=TEMP(3)
      CDSW=TEMP(4)
      AVBMSW=TEMP(5)
      READ (10) ZZZ
      REWIND 10
      GOTO 10
C
C    BLOCK 4 OPTION 2 REMOVED.       NO APENDAGES
C
  402 CONTINUE
      GOTO 10
```

```
C
C     STERNSEAL
C
500   CCNTINUE
      XSSI=TEMP(1)
      ZSSI=TEMP(2)
      ALEAK=TEMP(3)
      CFSS=TEMP(4)
      ELMAXS = TEMP(5)
      DPSS=TEMP(6)
      XLF=TEMP(7)
      ARGA = ELMAXS/XLF
      CCSTH = ARGA
      THSSI = ARCOS(ARGA)
      SINTH = SIN(THSSI)
      GC TO 10
C
C     BCWSEAL
C
 600  GC TO(610,620),IOPT
 610  CCNTINUE
      XBSI=TEMP(1)
      CFBS=TEMP(2)
      DPBS=TEMP(3)
      ZBSI=TEMP(4)
      ELMAXB = TEMP(5)
      XBF=TEMP(6)
      BLEAK=TEMP(7)
      GOTO 10
 620  CENCAB=TEMP(1)
      GC TO 10
C
C     PLENUM
C
700   CCNTINUE
      GO TO (705,710),IOPT
 705  CCNTINUE
      XLBW=TEMP(1)
      XBBW=TEMP(2)
      XPWV=TEMP(3)
      WIDTH=TEMP(4)
      XL=TEMP(5)
      XCPO=TEMP(6)
      BUBHGT=TEMP(7)
      XLXPWV=XLBW-XPWV
      PWVHT=(XPWV*XPWV-XLXPWV*XLXPWV)*.5/XL
      XPWVXS=XPWV-XS
      AEW=XBBW*XLBW
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      AB=WIDTH*XL                                                       INCN3090
      VCLNOM=(ABW+AB)*BUBHGT/2.                                         INCN3100
      GOTO 10                                                           INCN3110
  710 CONTINUE                                                          INCN3120
      FNCRIT=TEMP(1)                                                    INCN3130
      GO TO 10                                                          INCN3140
C                                                                       INCN3150
C     PROPULSION                                                        INCN3160
C                                                                       INCN3170
800   CONTINUE                                                          INCN3180
      GO TO (805,810),IOPT                                              INCN3190
  805 CONTINUE                                                          INCN3200
      XPO=TEMP(1)                                                       INCN3210
      YPO=TEMP(2)                                                       INCN3220
      ZPO=TEMP(3)                                                       INCN3230
      GO TO 10                                                          INCN3240
C                                                                       INCN3250
C BLOCK 8 OPTION 2 REMOVED. ENGINE OUT INPUT IN BLOCK 16                INCN3260
C                                                                       INCN3270
  810 CONTINUE                                                          INCN3280
      GOTO 10                                                           INCN3290
C                                                                       INCN3300
C     RUDDER                                                            INCN3310
C                                                                       INCN3320
900   CONTINUE                                                          INCN3330
      GO TO (905,910,915),IOPT                                          INCN3340
  905 XRO = TEMP(1)                                                     INCN3350
      YR=TEMP(2)                                                        INCN3360
      ZRO = TEMP(3)                                                     INCN3370
      RSPAN=TEMP(4)                                                     INCN3380
      RASPR=TEMP(5)                                                     INCN3390
      RAREA=TEMP(6)                                                     INCN3400
      RCLB=2.*PI*RASPR/(RASPR+3.)                                       INCN3410
      RTC=TEMP(7)                                                       INCN3420
      GO TO 10                                                          INCN3430
C                                                                       INCN3440
C     910 NOT USED                                                      INCN3450
C                                                                       INCN3460
  910 CONTINUE                                                          INCN3470
      GO TO 10                                                          INCN3480
  915 CONTINUE                                                          INCN3490
      GOTO 10                                                           INCN3500
C                                                                       INCN3510
C     AERODYNAMICS                                                      INCN3520
C                                                                       INCN3530
1000  CONTINUE                                                          INCN3540
      XLAERO=TEMP(1)                                                    INCN3550
      BEAM=TEMP(2)                                                      INCN3560
```

```
      RHOA=.5*RHOINF*XLAERO*BEAM
      GOTO 10
C
C     WAVES
C
1100  CONTINUE
      IWAVSW=IOPT
      IF(IWAVSW.GT.4) GO TO 70
      NWAVE=TEMP(1)
      IF(NWAVE .EQ. 0) GOTO 10
      IF(NWAVE .GT. 10) GOTO 70
      BETAD=TEMP(2)
      BETA=BETAD/RAD
      COSBET=COS(BETA)
      SINBET=SIN(BETA)
      TC = 1.0
      GO TO (1104,1106,1108,1108),IWAVSW
1104  DO 1105 I=1,NWAVE
1105  READ(5,1190) OMEGA(I),AW(I)
      GOTO 10
1106  DO 1107 I=1,NWAVE
1107  READ (5,1190) WAVLEN(I) ,AW(I)
      GOTO 10
 1108 SHTWV=TEMP(3)
      G1G=32.17
      G2=G1G*G1G
      G4=G2*G2
      GOTO(10,10,1110,1111),IWAVSW
 1110 CONTINUE
      PERL=TEMP(4)
      PERH=TEMP(5)
      WWN=(2.0*3.141592)*(1.0/PERH)
      WWX=(2.0*3.141592)*(1.0/PERL)
      GO TO 1112
 1111 CONTINUE
      WWN = TEMP(4)
      WWX = TEMP(5)
 1112 CONTINUE
      UUU=SQRT(SHTWV/0.0185)*1.6878
      UU4=UUU**4.
      CCC=(WWX/WWN)**(1./NWAVE)
      WWPO =WWN
      DO 1113 I = 1,NWAVE
      WWPN = WWPO*CCC
      WW =(WWPN+WWPO)/2
      DDW = WWPN-WWPO
      WWPO  = WWPN
      WW4= WW**4.0
```

```
      WW5 = WW**5.0                                                     INCN4050
      SS = 0.0081*G2/(EXP(0.74*G4/(WW4*UU4))*WW5)                       INCN4060
      CMEGA(I) =WW                                                      INCN4070
      AW(I) = SQRT(2.*SS*DDW)                                           INCN4080
 1113 CONTINUE                                                          INCN4090
      GC TO 10                                                          INCN4100
C                                                                       INCN4110
C     INITIAL CONDITIONS                                                INCN4120
C                                                                       INCN4130
1200  CCNTINUE                                                          INCN4140
      UC = TEMP(1)                                                      INCN4150
      THETO = TEMP(2)                                                   INCN4160
      DSC = TEMP(3)                                                     INCN4170
      DELPI=TEMP(4)                                                     INCN4180
      DPHI = TEMP(5)                                                    INCN4190
      GC TO 10                                                          INCN4200
1300  CONTINUE                                                          INCN4210
C                                                                       INCN4220
C     INPUT COMPLETED. 1) PRINT ALL INPUT                               INCN4230
C                                                                       INCN4240
      WRITE(6,2004) TITLC                                               INCN4250
      WRITE (6,2001) STIME,FTIME,DELO,TPRINO,DELPNT                     INCN4260
      WRITE (6,2002) IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,IRUD,INCN4270
     1 IPROP,IAEROD,IRHS                                                INCN4280
      WRITE(6,2021) I3DOF,ISRGE,ITRIM,IDIA                              INCN4290
      WRITE (6,2029) PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMC7   INCN4300
      WRITE (6,2003) NEQS, (TOL(J),J=1,NEQS)                            INCN4310
      WRITE (6,219) WEIGHT,XS,ZS,AIXX,AIYY,AIZZ,AIXZ                    INCN4320
      WRITE(6,217)A,AIMAX                                               INCN4330
      WRITE (6,2018) NSTA                                               INCN4340
      WRITE (6,490) YSW,XLSW,CFSW,CDSW,VANGLE,VSPAN,VCHORD,VXO,VY,VZO,  INCN4350
     1 AVBMSW,VTC                                                       INCN4360
      WRITE (6,491) NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB     INCN4370
      IF (IMM.GT.0)  WRITE(6,1549)    (XMO(J),J=1,IMNX)                 INCN4380
      WRITE (6,1519) IMM,IMNX,IMNY,IBMFIL,BTIME,IMT                     INCN4390
      IF (IMM.GT.0)  WRITE(6,1559) (YMI(J),J=1,IMNY)                    INCN4400
      WRITE (6,2010) XLBW,XBBW                                          INCN4410
      WRITE (6,2011) XL,WIDTH,XCPO,VOLNOM,BUBHGT                        INCN4420
      WRITE (6,2020) DELPI                                              INCN4430
      WRITE(6,2009) FNCRIT,XLTOT                                        INCN4440
      WRITE (6,2028) ENBFAN,BRPM,ENMFAN,EMRPM,ENSFAN,SRPM               INCN4450
      WRITE (6,2013) XRO,YR,ZRO,RONO,RMAXO,RRATO,RREVO,DLRDO            INCN4460
     1  ,RSPAN,RASPR,RAREA,RCLB,RTC                                     INCN4470
      WRITE (6,2012)          XPO,YPO,ZPO                               INCN4480
      WRITE (6,2027) XLAERO,BEAM                                        INCN4490
      WRITE (6,2026) XBSI,CFBS,DPBS,ELMAXB                              INCN4500
      WRITE (6,2025) XSSI,ZSSI,ALEAK,CFSS,ELMAXS,DPSS,XLF               INCN4510
      WRITE (6,2017) UO,THETO,DSO                                       INCN4520
```

```
C
C                 AND 2) INITIALIZE VARIABLES FOR CALCS.
C
      DO 1302 I=1,40
 1302 VAL(I) = 0.0
      U = UO*1.6889
      XSS=-(XS-XSSI)
      ZSS=ZS-ZSSI
      THETA = THETO/RAD
      PHI = DPHI/RAD
      THEQL=THETA
      DS = DSO/12.
      Z=-ZS+DS
      ZEQUIL=Z
      PHIMAX=0.
      TRCLL=0.
      IRDS=0
      TL=0.0
C
C     WAVE PARAMETERS TABLE
C
      IF(NWAVE .EQ.0) GOTO 1321
      AMPTC=1.30287
      GOTO(1310,1315),IWAVSW
1310  DO 1311 I=1,NWAVE
1311  WAVLEN(I)=2.*PI*G/(OMEGA(I)*OMEGA(I))
      GOTO 1317
1315  DO 1316 I=1,NWAVE
1316  OMEGA(I)=SQRT(2.*PI*G/WAVLEN(I))
1317  CONTINUE
C
C     CALCULATE INITIAL FREQUENCIES OF ENCOUNTER
C
      DO 1318 I=1,NWAVE
      WAVSLP(I) = 360.0*AW(I)/WAVLEN(I)
      OMEGAE(I) =2.*PI*(SQRT(G*WAVLEN(I)/(2.*PI))-U*COSBET)/WAVLEN(I)
      ENCPER(I) = 2.0*PI/OMEGAE(I)
1318  CONTINUE
      WRITE (6,1191) NWAVE,BETAD,(OMEGA(I),OMEGAE(I),WAVLEN(I),AW(I),
     1               WAVSLP(I),ENCPER(I),I=1,NWAVE)
      GOTO 1322
 1321 WRITE (6,1192)
1322  CONTINUE
      DO 1303 I=1,4
      DO 1303 N=1,11
 1303 ETA(I,N) = 0.0
      DVCLW = 0.0
      FXWAV = 0.0
```

```
      FYWAV = 0.0                                                       INCN5010
      FZWAV = 0.0                                                       INCN5020
      FKWAV = 0.0                                                       INCN5030
      FMWAV = 0.0                                                       INCN5040
      FNWAV = 0.0                                                       INCN5050
      ZBAR=Z                                                            INCN5060
      PHIBAR=PHI                                                        INCN5070
      THEBAR=THETA                                                      INCN5080
      TIME=STIME                                                        INCN5090
      DELT = DELO                                                       INCN5100
      TPRINT=TPRINO-DELPNT                                              INCN5110
      PWVCON=4.*WEIGHT/(RHO*G*XLBW)                                     INCN5120
      FNCON=SQRT(XLBW*G)                                                INCN5130
      VX=VXO-XS                                                         INCN5140
      VZ = ZS-VZO                                                       INCN5150
      XP=XPO-XS                                                         INCN5160
      XR = XRO-XS                                                       INCN5170
      YP=YPO                                                            INCN5180
      ZP=ZS-ZPO                                                         INCN5190
      ZR = ZS-ZRO                                                       INCN5200
      IF (IMM.EQ. 0) GO TO 1305                                         INCN5210
      DO 1304 J=1,IMNX                                                  INCN5220
 1304 XMI(J) = XMO(J) - XS                                              INCN5230
 1305 CONTINUE                                                          INCN5240
      XCP = XCPO-XS                                                     INCN5250
      ZCP = ZS-BUBHGT                                                   INCN5260
      XBS=XBSI-XS                                                       INCN5270
      N=NSTA(3)                                                         INCN5280
      ZBS=ZS-ZBSI                                                       INCN5290
      DO 1364 J=1,N                                                     INCN5300
      DELYBS=XBBW/(N-1)                                                 INCN5310
       XX(3,J)=XBS-XSSI                                                 INCN5320
      YY(3,J)=-0.5*XBBW+(J-1)*DELYBS                                    INCN5330
 1364 CONTINUE                                                          INCN5340
      N=N-1                                                             INCN5350
      DO 1367 J=1,N                                                     INCN5360
      YAVGB(J)=(YY(3,J+1)+YY(3,J))/2.                                   INCN5370
 1367 CONTINUE                                                          INCN5380
      N=NSTA(4)                                                         INCN5390
      DELYSS=XBBW/(N-1)                                                 INCN5400
      DO 1365 J=1,N                                                     INCN5410
      XX(4,J)=-XS                                                       INCN5420
      YY(4,J)=-.5*XBBW+(J-1)*DELYSS                                     INCN5430
 1365 CONTINUE                                                          INCN5440
      N=N-1                                                             INCN5450
      DO 1368 J=1,N                                                     INCN5460
      YAVGS(J)=(YY(4,J+1)+YY(4,J))/2.                                   INCN5470
 1368 CONTINUE                                                          INCN5480
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```
      XBOW=XLTOT-XS                                                     INCN5490
      N=NSTA(1)                                                         INCN5500
      DELX=XBSI/(N-1)                                                   INCN5510
      DO 1309 J=1,2                                                     INCN5520
      DO 1309 I=1,N                                                     INCN5530
      XX(J,I)=(I-1)*DELX-XS                                             INCN5540
 1309 YY(J,I)= YSW*(2*J-3)                                              INCN5550
      WRITE(6,1366) ((XX(J,N),N=1,11),(YY(J,N),N=1,11),J=1,4)           INCN5560
 1366 FORMAT (//17H XX AND YY ARRAYS /14H PORT SIDEWALL /2(11F10.2/),   INCN5570
     1 15H STBD. SIDEWALL /2(11F10.2/),9H BOW SEAL /2(11F10.2/),        INCN5580
     2 11H STERN SEAL /2(11F10.2/))                                     INCN5590
      N=NSTA(1)-1                                                       INCN5600
      DO 1308 I=1,N                                                     INCN5610
 1308 XAVG(I)=DELX*(2*I-1)/2.-XS                                        INCN5620
C                                                                       INCN5630
      CALL WAVES(TIME)                                                  INCN5640
C                                                                       INCN5650
C     INITIALIZE BUBBLE PRESSURE, ABSOLUTE (PSF)                        INCN5660
C                                                                       INCN5670
      PB=PINF+DELPI                                                     INCN5680
      PBBAR=DELPI                                                       INCN5690
      PBAR=DELPI                                                        INCN5700
      PSS=PB+DPSS                                                       INCN5710
      PBS=PB+DPBS                                                       INCN5720
      AB=ABW-(ABW-AB)*(ZS+Z/BUBHGT)                                     INCN5730
      CF=.37/((U/FNCON)**1.5655981)                                     INCN5740
      WATSLP=PBBAR*CF*PWVCON/WEIGHT                                     INCN5750
      IF (IDIA.EQ.1) GO TO 6                                            INCN5760
      VOL=VOLNOM-.5*(AB+ABW)*(Z+ZS)-DVOLW                               INCN5770
     1+.5*WATSLP*XL*AB                                                  INCN5780
      GO TO 7                                                           INCN5790
 6    VOL=VOLNOM-.5*(AB+ABW)*(Z+ZS)-DVOLW+PBAR*.3175333                 INCN5800
 7    CONTINUE                                                          INCN5810
      BMASS=(PB/PINF)**(1./GAM)*VOL*RHOINF                              INCN5820
      WRITE (6,2023)                                                    INCN5830
      RETURN                                                            INCN5840
C                                                                       INCN5850
C     RUN TERMINATOR                                                    INCN5860
C                                                                       INCN5870
 1400 WRITE(6,98)                                                       INCN5880
      STOP                                                              INCN5890
C                                                                       INCN5900
C     BENDING MOMENT                                                    INCN5910
C                                                                       INCN5920
 1500 GO TO (1510,1520,1530,1540), IOPT                                 INCN5930
 1510 IMM = TEMP(1)                                                     INCN5940
      IF (IMM.GT.3)  GO TO 70                                           INCN5950
      IMNX = TEMP(2)                                                    INCN5960
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      IF (IMNX.GT.10)  GO TO 70                                         INCN5970
      IMNY = TEMP(3)                                                    INCN5980
      IF (IMNY.GT.7)  GO TO 70                                          INCN5990
      IBMFIL = TEMP(4)                                                  INCN6000
      BTIME = TEMP(5)                                                   INCN6010
      IF (IMM.EQ.3)  IMT = TEMP(6)                                      INCN6020
      GO TO 10                                                          INCN6030
 1520 DO 1521 J=1,7                                                     INCN6040
 1521 XMO(J) = TEMP(J)                                                  INCN6050
      IF (IMNX.LE.7)  GO TO 10                                          INCN6060
      READ 1522, (XMO(J),J=8,IMNX)                                      INCN6070
      GO TO 10                                                          INCN6080
 1530 DO 1531 J=1,IMNY                                                  INCN6090
 1531 YMI(J) = TEMP(J)                                                  INCN6100
      GO TO 10                                                          INCN6110
 1540 CONTINUE                                                          INCN6120
      GO TO 10                                                          INCN6130
1600  CONTINUE                                                          INCN6140
      GO TO(1605,1610,1615),ICPT                                        INCN6150
 1605 CONTINUE                                                          INCN6160
C                                                                       INCN6170
C   VALUES INPUT FOR STBD SCREW                                         INCN6180
C                                                                       INCN6190
      THST1=TEMP(1)                                                     INCN6200
      NPS=TEMP(2)                                                       INCN6210
      STHS=TEMP(3)                                                      INCN6220
      IF(NPS.EQ.0.0) GO TO 1609                                         INCN6230
      READ(5,1950)(TIS(J),J=1,NPS)                                      INCN6240
      READ(5,1950)(THSTS(J),J=1,NPS)                                    INCN6250
      GO TO 10                                                          INCN6260
 1609 THSTS(1)=THST1                                                    INCN6270
 1610 CONTINUE                                                          INCN6280
C                                                                       INCN6290
C   VALUES INPUT FOR PORT SCREW                                         INCN6300
C                                                                       INCN6310
      THST2=TEMP(1)                                                     INCN6320
      NPP=TEMP(2)                                                       INCN6330
      STHP=TEMP(3)                                                      INCN6340
      IF(NPP.EQ.0.0) GO TO 1614                                         INCN6350
      READ(5,1950)(TIP(J),J=1,NPP)                                      INCN6360
      READ(5,1950)(THSTP(J),J=1,NPP)                                    INCN6370
      GO TO 10                                                          INCN6380
 1614 THSTP(1)=THST2                                                    INCN6390
 1615 CONTINUE                                                          INCN6400
C                                                                       INCN6410
C   VALUES INPUT FOR RUDDER                                             INCN6420
C                                                                       INCN6430
      DELR=TEMP(1)                                                      INCN6440
```

```
      NPR=TEMP(2)                                                       INCN6450
      IF(NPR.EQ.0.0) GO TO 1616                                         INCN6460
      READ(5,1950)(TIR(J),J=1,NPR)                                      INCN6470
      READ(5,1950)(DELRUD(J),J=1,NPR)                                   INCN6480
      GO TO 10                                                          INCN6490
 1616 DELRUD(1)=DELR                                                    INCN6500
      GO TO 10                                                          INCN6510
 1700 GO TO (1705,1710),IOPT                                            INCN6520
 1705 NB=TEMP(1)                                                        INCN6530
      READ(5,1950)(TMEB(I),I=1,NB)                                      INCN6540
      READ(5,1950)(DELB(I),I=1,NB)                                      INCN6550
      GO TO 10                                                          INCN6560
 1710 NS=TEMP(1)                                                        INCN6570
      READ(5,1950)(TMES(I),I=1,NS)                                      INCN6580
      READ(5,1950)(DETS(I),I=1,NS)                                      INCN6590
      GOTO 10                                                           INCN6600
C                                                                       INCN6610
C     TITLE CARD (ALL 80 COLUMNS )                                      INCN6620
C                                                                       INCN6630
 1800 READ  (5,2022)  TITLC                                             INCN6640
      GO TO 10                                                          INCN6650
C                                                                       INCN6660
C     FAN MAPS                                                          INCN6670
C                                                                       INCN6680
1900  CONTINUE                                                          INCN6690
      GO TO (1905,1910,1915),IOPT                                       INCN6700
1905  CONTINUE                                                          INCN6710
      ENBFAN=TEMP(1)                                                    INCN6720
      BRPM=TEMP(2)                                                      INCN6730
      NPTSB=TEMP(3)                                                     INCN6740
      READIN=TEMP(4)                                                    INCN6750
      IF (READIN .EQ. 0.0) GO TO 10                                     INCN6760
      READ (5,1950) (PBFAN(J),J=1,NPTSB)                                INCN6770
      READ (5,1950) (QBFAN(J),J=1,NPTSB)                                INCN6780
      GO TO 10                                                          INCN6790
1910  CONTINUE                                                          INCN6800
      ENMFAN=TEMP(1)                                                    INCN6810
      EMRPM=TEMP(2)                                                     INCN6820
      NPTSM=TEMP(3)                                                     INCN6830
      READIN=TEMP(4)                                                    INCN6840
      IF (READIN .EQ. 0.0) GO TO 10                                     INCN6850
      READ (5,1950) (PMFAN(J),J=1,NPTSM)                                INCN6860
      READ (5,1950) (QMFAN(J);J=1,NPTSM)                                INCN6870
      GO TO 10                                                          INCN6880
1915  CONTINUE                                                          INCN6890
      ENSFAN=TEMP(1)                                                    INCN6900
      SRPM=TEMP(2)                                                      INCN6910
      NPTSS=TEMP(3)                                                     INCN6920
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      READIN=TEMP(4)                                                    INCN6930
      IF (READIN .EQ. 0.0) GO TO 10                                     INCN6940
      READ (5,1950) (PSFAN(J),J=1,NPTSS)                                INCN6950
      READ (5,1950) (QSFAN(J),J=1,NPTSS)                                INCN6960
      GO TO 10                                                          INCN6970
1950  FORMAT(8F10.0)                                                    INCN6980
C                                                                       INCN6990
C     ERROR IN INPUT                                                    INCN7000
C                                                                       INCN7010
   70 CONTINUE                                                          INCN7020
      WRITE (6,79) ISYS                                                 INCN7030
      STOP                                                              INCN7040
C                                                                       INCN7050
  79  FORMAT(34H INPUT ERROR - - - STOP - -  ISYS= ,I3)                 INCN7060
  98  FORMAT(1H1,20(/),50X,19H COMPLETED ALL RUNS )                     INCN7070
99    FORMAT(I3,I2,7F10.0)                                              INCN7080
 191  FORMAT (16I5)                                                     INCN7090
 192  FORMAT (5F10.0)                                                   INCN7100
  195 FORMAT(///10X,65HERROR IN INPUT --- DELT AND/OR DELPNT EQUALS ZEROINCN7110
     1 --- JOB ABORTED )                                                INCN7120
 175  FORMAT (2I2/(8F10.0))                                             INCN7130
  216 FORMAT(///10X,82HERROR IN INPUT --- INPUT INERTIA ELEMENTS LEAD TOINCN7140
     1 ZERO DETERMINANT --- JOB ABORTED )                               INCN7150
  217 FORMAT(22H INERTIA MATRIX, AIMAX  6E15.4/(22X,6E15.4))            INCN7160
  219 FORMAT(30H WEIGHT, C.G., INERTIA MOMENTS 7F12.3)                  INCN7170
  305 FORMAT ( 11F7.0 )                                                 INCN7180
  490 FORMAT(15H SIDEWALL INPUT 12(F8.3,1X))                            INCN7190
  491 FORMAT(26H SIDEWALL TABLE PARAMETERS 4(I4,F7.3,F7.3))             INCN7200
1190  FORMAT(2F10.0)                                                    INCN7210
 1191 FORMAT(/12HONO OF WAVES I2,10H BETA(DEG)F5.0/15H OMEGA(RAD/SEC) , INCN7220
     15X,16H OMEGAE(RAD/SEC) 5X,16H WAVE LENGTH(FT) 5X,14H AMPLITUDE(FT)INCN7230
     - 5X,16HMAX  SLOPE (DEG)5X,13HPERIOD,E(SEC)/(F8.4,12X,F8.4,4F20.3))INCN7240
 1192 FORMAT(/11HOCALM WATER)                                           INCN7250
 1519 FORMAT(32HOMOMENT CALC. CONTROL PARAMETERS 4I5, F8.3, I5 )        INCN7260
 1522 FORMAT ( 5X,7F10.0)                                               INCN7270
 1549 FORMAT(22H MOMENT CALCS. AT X OF 11F10.3)                         INCN7280
 1559 FORMAT(22H MOMENT CALCS. AT Y OF 11F10.3)                         INCN7290
 2004 FORMAT(33H1SES MOTIONS AND LOADS PROGRAM - 20A4,/)                INCN7300
 2001 FORMAT(23H START AND FINISH TIMES 2F10.2/                         INCN7310
     -22H INITIAL TIME INTERVAL F12.4/                                  INCN7320
     -18H START PRINTING AT F8.2,17H IN INCREMENTS OF F8.2)             INCN7330
 2002 FORMAT(24H INTERMEDIATE PRINT TAGS 16I5)                          INCN7340
 2003 FORMAT(39H NO. OF STATE EQUATIONS, AND TOLERANCESI5/(10X,10E12.2))INCN7350
 2009 FORMAT(23HOCRITICAL FROUDE NUMBER F15.4,5X,19H TOTAL CRAFT LENGTH INCN7360
     1          F15.4)                                                  INCN7370
 2010 FORMAT(34HOPLENUM, LENGTH AND WIDTH AT WATER 2F12.4)              INCN7380
 2011 FORMAT(34H PLENUM, LENGTH AND WIDTH AT HULL  2F12.4/              INCN7390
     -          35H PLENUM, CENTER OF PRESSURE AT HULL F12.4/           INCN7400
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     -23H PLENUM, NOMINAL VOLUME F12.1,10X, 6HHEIGHT F12.4)
 2012 FORMAT(/33H PROPULSION, X, Y, Z COORDINATES  3F12.4/)
 2013 FCRMAT(/28HORUDDER, X, Y, Z COORDINATES  3F12.4/
     -        41H RUDDER, ON, MAX, RATE, REVERSE, INITIAL  5F12.4/
     -        33H RUDDER,SPAN,ASPECT,AREA,CLB,T/C  5F12.4)
 2017 FORMAT(/39HOINITIAL CONDITIONS, VELOCITY (KNOTS) = F7.2, 5X,
     -        13HPITCH (DEG) = F8.3,5X,12HDRAFT (IN) = F8.2)
 2018 FORMAT( 49H NUMBER OF STATIONS, SIDEWALLS (P+S), SEALS (B+S) ,4I5)
 2020 FORMAT( 38H PLENUM, INITIAL PRESSURE, GAGE (PSF)  F8.2)
 2021 FORMAT(79H PROGRAM OPTION SWITCH SETTINGS (LATERAL PLANE,CONSTANT
     -SPEED,TRIM,MEMBRANE)     7I5)
 2022 FCRMAT (20A4 )
 2023 FORMAT ( 1H1 )
 2025 FORMAT( 16H STERNSEAL INPUT  7F12.4 )
 2026 FORMAT( 16H BOWSEAL INPUT    7F12.4 )
 2027 FORMAT( 19HOAERODYNAMICS INPUT  7F12.4)
 2028 FORMAT( 33HOFANS, NO. + RPM, BOW,MAIN,STERN  3(F10.0,F10.1))
 2029 FCRMAT(32H PROGRAM MODIFICATION SETTINGS        7(F12.4,1X))
      END

C
      SUBROUTINE DMINV (A,N,D)
C
      DIMENSION A(6,6),PIVOT(6)
      DIMENSICN IPVOT(6),INDEX(6,2)
      EQUIVALENCE (IROW,JROW),(ICOL,JCOL)
C
      D=1.0
      DC 17 J=1,N
      IPVOT(J)=0
   17 CONTINUE
      DO 135 I=1,N
      T=0.0
        DO 9 J=1,N
      IF(IPVOT(J)-1) 13,9,13
   13 DO 23 K=1,N
      IF(IPVOT(K)-1) 43,23,81
   43 IF (ABS(T)-ABS(A(J,K))) 83,23,23
   83 IROW=J
      ICCL=K
      T=A(J,K)
   23 CONTINUE
    9 CCNTINUE
      IPVOT(ICOL)=IPVOT(ICOL)+1
      IF(IROW-ICOL) 73,109,73
   73 D=-D
      DC 12 L=1,N
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```
      T=A(IROW,L)                                                        DMV 0280
      A(IROW,L)=A(ICOL,L)                                                DMV 0290
      A(ICOL,L)=T                                                        DMV 0300
   12 CONTINUE                                                           DMV 0310
  109 INDEX(I,1)=IROW                                                    DMV 0320
      INDEX(I,2)=ICOL                                                    DMV 0330
      PIVOT(I)=A(ICOL,ICOL)                                              DMV 0340
      D=D*PIVOT(I)                                                       DMV 0350
      A(ICOL,ICOL)=1.0                                                   DMV 0360
      DO 205 L=1,N                                                       DMV 0370
      A(ICOL,L)=A(ICOL,L)/PIVOT(I)                                       DMV 0380
  205 CONTINUE                                                           DMV 0390
      DO 134 LI=1,N                                                      DMV 0400
      IF(LI-ICOL) 21,134,21                                              DMV 0410
   21 T=A(LI,ICOL)                                                       DMV 0420
      A(LI,ICOL)=0.0                                                     DMV 0430
      DO 89 L=1,N                                                        DMV 0440
      A(LI,L)=A(LI,L)-A(ICOL,L)*T                                        DMV 0450
   89 CONTINUE                                                           DMV 0460
  134 CONTINUE                                                           DMV 0470
  135 CONTINUE                                                           DMV 0480
      DO 3 I=1,N                                                         DMV 0490
      L=N-I+1                                                            DMV 0500
      IF(INDEX(L,1)-INDEX(L,2)) 19,3,19                                  DMV 0510
   19 JROW=INDEX(L,1)                                                    DMV 0520
      JCOL=INDEX(L,2)                                                    DMV 0530
      DO 549 K=1,N                                                       DMV 0540
      T=A(K,JROW)                                                        DMV 0550
      A(K,JROW)=A(K,JCOL)                                                DMV 0560
      A(K,JCOL)=T                                                        DMV 0570
  549 CONTINUE                                                           DMV 0580
    3 CONTINUE                                                           DMV 0590
C                                                                        DMV 0600
   81 RETURN                                                             DMV 0610
      END                                                                DMV 0620


C                                                                        WAVS0010
      SUBROUTINE WAVES(TIME)                                             WAVS0020
C                                                                        WAVS0030
      INTEGER ON                                                         WAVS0040
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYWAVS0050
      COMMON /CONST/ PI,RAD,UO                                           WAVS0060
      COMMON /GEOM/     WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM     WAVS0070
     1,DELS(4,10),XCP,ZCP                                                WAVS0080
      COMMON /GEOMBS/DETABX(11),DETABT(11),ARM1B(10),ARM2B(10)           WAVS0090
     1 ,DFBS(10),TSKIB(10)                                               WAVS0100
      COMMON /GEOMSS/DETADX(11),DETADT(11),ARM1S(10),DFSS(10),TSKIS(10)  WAVS0110
```

```
     1 ,ARM2S(10)                                                       WAVS0120
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  WAVS0130
     -                AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO       WAVS0140
      COMMON /MWAVE/ FXW(2),FYW(2),FZW(2),FKW(2),FMW(2),FNW(2)          WAVS0150
      COMMON /PLENUM/XLBW,XBBW,ABW,BUBHGT                               WAVS0160
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  WAVS0170
     -IRUD,IPROP,IAEROD,IRHS                                            WAVS0180
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7  WAVS0190
      COMMON /RISER/ AMPTC                                              WAVS0200
      COMMON /SIDE/FXSW,FYSW,FZSW,FKSW,FMSW,FNSW,ALSW,YSW,XLSW,CFSW,CDSWWAVS0210
     1,VAREA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY,VZ  ,AVBMSW,DELX,VTC      WAVS0220
      COMMON /VARBLE/ VAL(40)                                           WAVS0230
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVCLW,NWAVE,BETA,        WAVS0240
     1              FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                 WAVS0250
     2              ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR          WAVS0260
      COMMON /WAVTAB/ NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,  WAVS0270
     1         AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),         WAVS0280
     2         AC5(20,5,7),AC6(20,5,7),AC7(20,5,7)                      WAVS0290
     3         ,AC0(20,5,7),AC00(20,5,7),AC8(20,5,7),                   WAVS0300
     4         AS1(20,5,7),AS2(20,5,7),AS3(20,5,7),AS4(20,5,7),         WAVS0310
     5         AS5(20,5,7),AS6(20,5,7),AS7(20,5,7)                      WAVS0320
     6         ,AS0(20,5,7),AS00(20,5,7),AS8(20,5,7)                    WAVS0330
     7         ,BB(36),XREF,RX                                          WAVS0340
      DIMENSION WC0(2),WC00(2),WC1(2),WC2(2),WC3(2),WC4(2),WC5(2),WC6(2)WAVS0350
     1         ,WC7(2),WC8(2)                                           WAVS0360
      DIMENSION WS0(2),WS00(2),WS1(2),WS2(2),WS3(2),WS4(2),WS5(2),WS6(2)WAVS0370
     1         ,WS7(2),WS8(2)                                           WAVS0380
      EQUIVALENCE            (VAL(2),U),(VAL(3),V),(VAL(4),W),          WAVS0390
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     WAVS0400
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),WAVS0410
     3(VAL(24),PB)                                                      WAVS0420
      EQUIVALENCE (VAL(16),ETACG)                                       WAVS0430
C                                                                       WAVS0440
      IF (NWAVE.EQ.0) RETURN                                            WAVS0450
C                                                                       WAVS0460
C     CALCULATION OF SHIFT OF XCPO                                      WAVS0470
C                                                                       WAVS0480
      XCPU=XCP+0.001975*(U*0.5921-30.0)**2-0.974                        WAVS0490
      XCPC=SHXYAX(XCPU,ZCP,THETA,PI)                                    WAVS0500
      GAMMA=BETA-PSI                                                    WAVS0510
      SIGAM=SIN(GAMMA)                                                  WAVS0520
      COGAM=COS(GAMMA)                                                  WAVS0530
      FO= -X*COSBET -Y*SINBET                                           WAVS0540
      DVCLW=0.0                                                         WAVS0550
      ETACG=0.0                                                         WAVS0560
      N=NSTA(3)                                                         WAVS0570
      DO 1 J=1,N                                                        WAVS0580
      DETABX(J)=0.0                                                     WAVS0590
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    1 CONTINUE                                                          WAVS0600
      N=NSTA(4)                                                         WAVS0610
      DO 2 J=1,N                                                        WAVS0620
      DETADX(J)=0.0                                                     WAVS0630
    2 CONTINUE                                                          WAVS0640
      DO 10 J=1,4                                                       WAVS0650
      N=NSTA(J)                                                         WAVS0660
      DO 10 K=1,N                                                       WAVS0670
10    ETA(J,K)=0.0                                                      WAVS0680
      DO 15 J=1,2                                                       WAVS0690
      FXW(J) = 0.0                                                      WAVS0700
      FYW(J) = 0.0                                                      WAVS0710
      FZW(J) = 0.0                                                      WAVS0720
      FKW(J) = 0.0                                                      WAVS0730
      FMW(J) = 0.0                                                      WAVS0740
      FNW(J) = 0.0                                                      WAVS0750
   15 CONTINUE                                                          WAVS0760
      XSS = -XS                                                         WAVS0770
      IF (IMT.EQ.2)  XSS = XMI(IX)                                      WAVS0780
      IP = 1  +(THEBAR*RAD-STH)/DTH                                     WAVS0790
      IP=MAXO(MINO(IP,NTH),1)                                           WAVS0800
      IP1=MINO(IP+1,NTH)                                                WAVS0810
      DTHETA=(IP-1)*DTH+STH                                             WAVS0820
      DIP= (THETA*RAD-DTHETA)/DTH                                       WAVS0830
C     TIME RISE FACTOR FOR WAVE AMPLITUDE                               WAVS0840
      AMPFAC=1.-EXP(-TIME/AMPTC)                                        WAVS0850
      DO 100 I=1,NWAVE                                                  WAVS0860
      OM1=OMEGA(I)                                                      WAVS0870
      OM2=OM1*OM1                                                       WAVS0880
      XWK=OM2/G                                                         WAVS0890
      AA=AW(I)*AMPFAC                                                   WAVS0900
      FT= OM1*TIME+XWK*FO                                               WAVS0910
      AL=XWK*COGAM                                                      WAVS0920
      IAA= 1+(ABS(AL)-SAL)/DAL                                          WAVS0930
      IAA=MAXO(MINO(IAA,NAL),1)                                         WAVS0940
      IAA1=MINO(IAA+1,NAL)                                              WAVS0950
      DAA= (IAA-1)*DAL+SAL                                              WAVS0960
      DIA= (ABS(AL)-DAA)/DAL                                            WAVS0970
      SALP=SIGN(1.,AL)                                                  WAVS0980
C                                                                       WAVS0990
C     WAVE FORCES AND MOMENTS ON THE SIDEWALLS                          WAVS1000
C                                                                       WAVS1010
      DO 40 J=1,2                                                       WAVS1020
      YLSW=(2*J-3)*YSW                                                  WAVS1030
      WE=FT+XWK*SIGAM*YLSW                                              WAVS1040
      ST=SIN(WE)                                                        WAVS1050
      CT=COS(WE)                                                        WAVS1060
      DS= ZBAR+ZS+YLSW*PHIBAR                                           WAVS1070
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      DSR=DS-(XREF-XS)*THEBAR                                           WAVS1080
      ID=1.+(DSR*12.-SDS)/DDS                                           WAVS1090
      ID=MAX0(MIN0(ID,NDS),1)                                           WAVS1100
      DDSR =(ID-1)*DDS  +SDS                                            WAVS1110
      DID= (DSR*12.-DDSR)/DDS                                           WAVS1120
      ID1=MIN0(ID+1,NDS)                                                WAVS1130
      DSS=DS-XSS*THEBAR                                                 WAVS1140
      ZOR1=(SIGN(1.,DSS)+1.)/2.                                         WAVS1150
      DSS=DSS*ZOR1                                                      WAVS1160
      IDSS=1.5+(DSS-SBB)/DBB                                            WAVS1170
      IDSS=MIN0(NBB,IDSS)                                               WAVS1180
      BS=BB(IDSS)                                                       WAVS1190
      CK = COS(XWK*COGAM*XSS)                                           WAVS1200
      A33S=(RHO*PI*BS**2)/8.                                            WAVS1210
      SK = SIN(XWK*COGAM*XSS)                                           WAVS1220
      A22S=(RHO*.4*PI*DSS**2)/2.                                        WAVS1230
      A42S=0.0                                                          WAVS1240
C                                                                       WAVS1250
C     INTERPOLATION OF WAVE TABLES                                      WAVS1260
C                                                                       WAVS1270
      K=1                                                               WAVS1280
      L=IAA                                                             WAVS1290
41    CONTINUE                                                          WAVS1300
      BC0=AC0( L,ID,IP)                                                 WAVS1310
      BC00=AC00( L,ID,IP)                                               WAVS1320
      BC1=AC1( L,ID,IP)                                                 WAVS1330
      BC2=AC2( L,ID,IP)                                                 WAVS1340
      BC3=AC3( L,ID,IP)                                                 WAVS1350
      BC4=AC4( L,ID,IP)                                                 WAVS1360
      BC5=AC5( L,ID,IP)                                                 WAVS1370
      BC6=AC6( L,ID,IP)                                                 WAVS1380
      BC7=AC7( L,ID,IP)                                                 WAVS1390
      BC8=AC8( L,ID,IP)                                                 WAVS1400
      BS0=AS0( L,ID,IP)                                                 WAVS1410
      BS00=AS00( L,ID,IP)                                               WAVS1420
      BS1=AS1( L,ID,IP)                                                 WAVS1430
      BS2=AS2( L,ID,IP)                                                 WAVS1440
      BS3=AS3( L,ID,IP)                                                 WAVS1450
      BS4=AS4( L,ID,IP)                                                 WAVS1460
      BS5=AS5( L,ID,IP)                                                 WAVS1470
      BS6=AS6( L,ID,IP)                                                 WAVS1480
      BS7=AS7( L,ID,IP)                                                 WAVS1490
      BS8=AS8( L,ID,IP)                                                 WAVS1500
      WC0 (K)=BC0  +DID*(AC0  (L,ID1,IP)-BC0  )  +DIP*(AC0  (L,ID,IP1)-BC0    WAVS1510
     1   +DID*(AC0  (L,ID1,IP1)-AC0  (L,ID,IP1)-AC0  (L,ID1,IP)+BC0  ))   WAVS1520
      WC00(K)=BC00+DID*(AC00(L,ID1,IP)-BC00)  +DIP*(AC00(L,ID,IP1)-BC00   WAVS1530
     1   +DID*(AC00(L,ID1,IP1)-AC00(L,ID,IP1)-AC00(L,ID1,IP)+BC00))       WAVS1540
      WC1 (K)=BC1  +DID*(AC1  (L,ID1,IP)-BC1  )  +DIP*(AC1  (L,ID,IP1)-BC1    WAVS1550
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     1    +DID*(AC1 (L,ID1,IP1)-AC1 (L,ID,IP1)-AC1 (L,ID1,IP)+BC1 ))       WAVS1560
      WC2 (K)=BC2 +DID*(AC2 (L,ID1,IP)-BC2 ) +DIP*(AC2 (L,ID,IP1)-BC2      WAVS1570
     1    +DID*(AC2 (L,ID1,IP1)-AC2 (L,ID,IP1)-AC2 (L,ID1,IP)+BC2 ))       WAVS1580
      WC3 (K)=BC3 +DID*(AC3 (L,ID1,IP)-BC3 ) +DIP*(AC3 (L,ID,IP1)-BC3      WAVS1590
     1    +DID*(AC3 (L,ID1,IP1)-AC3 (L,ID,IP1)-AC3 (L,ID1,IP)+BC3 ))       WAVS1600
      WC4 (K)=BC4 +DID*(AC4 (L,ID1,IP)-BC4 ) +DIP*(AC4 (L,ID,IP1)-BC4      WAVS1610
     1    +DID*(AC4 (L,ID1,IP1)-AC4 (L,ID,IP1)-AC4 (L,ID1,IP)+BC4 ))       WAVS1620
      WC5 (K)=BC5 +DID*(AC5 (L,ID1,IP)-BC5 ) +DIP*(AC5 (L,ID,IP1)-BC5      WAVS1630
     1    +DID*(AC5 (L,ID1,IP1)-AC5 (L,ID,IP1)-AC5 (L,ID1,IP)+BC5 ))       WAVS1640
      WC6 (K)=BC6 +DID*(AC6 (L,ID1,IP)-BC6 ) +DIP*(AC6 (L,ID,IP1)-BC6      WAVS1650
     1    +DID*(AC6 (L,ID1,IP1)-AC6 (L,ID,IP1)-AC6 (L,ID1,IP)+BC6 ))       WAVS1660
      WC7 (K)=BC7 +DID*(AC7 (L,ID1,IP)-BC7 ) +DIP*(AC7 (L,ID,IP1)-BC7      WAVS1670
     1    +DID*(AC7 (L,ID1,IP1)-AC7 (L,ID,IP1)-AC7 (L,ID1,IP)+BC7 ))       WAVS1680
      WC8 (K)=BC8 +DID*(AC8 (L,ID1,IP)-BC8 ) +DIP*(AC8 (L,ID,IP1)-BC8      WAVS1690
     1    +DID*(AC8 (L,ID1,IP1)-AC8 (L,ID,IP1)-AC8 (L,ID1,IP)+BC8 ))       WAVS1700
      WS0 (K)=BS0 +DID*(AS0 (L,ID1,IP)-BS0 ) +DIP*(AS0 (L,ID,IP1)-BS0      WAVS1710
     1    +DID*(AS0 (L,ID1,IP1)-AS0 (L,ID,IP1)-AS0 (L,ID1,IP)+BS0 ))       WAVS1720
      WS00(K)=BS00+DID*(AS00(L,ID1,IP)-BS00) +DIP*(AS00(L,ID,IP1)-BS00     WAVS1730
     1    +DID*(AS00(L,ID1,IP1)-AS00(L,ID,IP1)-AS00(L,ID1,IP)+BS00))       WAVS1740
      WS1 (K)=BS1 +DID*(AS1 (L,ID1,IP)-BS1 ) +DIP*(AS1 (L,ID,IP1)-BS1      WAVS1750
     1    +DID*(AS1 (L,ID1,IP1)-AS1 (L,ID,IP1)-AS1 (L,ID1,IP)+BS1 ))       WAVS1760
      WS2 (K)=BS2 +DID*(AS2 (L,ID1,IP)-BS2 ) +DIP*(AS2 (L,ID,IP1)-BS2      WAVS1770
     1    +DID*(AS2 (L,ID1,IP1)-AS2 (L,ID,IP1)-AS2 (L,ID1,IP)+BS2 ))       WAVS1780
      WS3 (K)=BS3 +DID*(AS3 (L,ID1,IP)-BS3 ) +DIP*(AS3 (L,ID,IP1)-BS3      WAVS1790
     1    +DID*(AS3 (L,ID1,IP1)-AS3 (L,ID,IP1)-AS3 (L,ID1,IP)+BS3 ))       WAVS1800
      WS4 (K)=BS4 +DID*(AS4 (L,ID1,IP)-BS4 ) +DIP*(AS4 (L,ID,IP1)-BS4      WAVS1810
     1    +DID*(AS4 (L,ID1,IP1)-AS4 (L,ID,IP1)-AS4 (L,ID1,IP)+BS4 ))       WAVS1820
      WS5 (K)=BS5 +DID*(AS5 (L,ID1,IP)-BS5 ) +DIP*(AS5 (L,ID,IP1)-BS5      WAVS1830
     1    +DID*(AS5 (L,ID1,IP1)-AS5 (L,ID,IP1)-AS5 (L,ID1,IP)+BS5 ))       WAVS1840
      WS6 (K)=BS6 +DID*(AS6 (L,ID1,IP)-BS6 ) +DIP*(AS6 (L,ID,IP1)-BS6      WAVS1850
     1    +DID*(AS6 (L,ID1,IP1)-AS6 (L,ID,IP1)-AS6 (L,ID1,IP)+BS6 ))       WAVS1860
      WS7 (K)=BS7 +DID*(AS7 (L,ID1,IP)-BS7 ) +DIP*(AS7 (L,ID,IP1)-BS7      WAVS1870
     1    +DID*(AS7 (L,ID1,IP1)-AS7 (L,ID,IP1)-AS7 (L,ID1,IP)+BS7 ))       WAVS1880
      WS8 (K)=BS8 +DID*(AS8 (L,ID1,IP)-BS8 ) +DIP*(AS8 (L,ID,IP1)-BS8      WAVS1890
     1    +DID*(AS8 (L,ID1,IP1)-AS8 (L,ID,IP1)-AS8 (L,ID1,IP)+BS8 ))       WAVS1900
      IF(K .EQ. 2) GOTO 42                                                 WAVS1910
      K=2                                                                  WAVS1920
      L =IAA1                                                              WAVS1930
      GOTO 41                                                              WAVS1940
 42   BC0 = WC0 (1)+DIA*(WC0 (2)-WC0 (1))                                  WAVS1950
      BC00= WC00(1)+DIA*(WC00(2)-WC00(1))                                  WAVS1960
      BC1 = WC1 (1)+DIA*(WC1 (2)-WC1 (1))                                  WAVS1970
      BC2 = WC2 (1)+DIA*(WC2 (2)-WC2 (1))                                  WAVS1980
      BC3 = WC3 (1)+DIA*(WC3 (2)-WC3 (1))                                  WAVS1990
      BC4 = WC4 (1)+DIA*(WC4 (2)-WC4 (1))                                  WAVS2000
      BC5 = WC5 (1)+DIA*(WC5 (2)-WC5 (1))                                  WAVS2010
      BC6 = WC6 (1)+DIA*(WC6 (2)-WC6 (1))                                  WAVS2020
      BC7 = WC7 (1)+DIA*(WC7 (2)-WC7 (1))                                  WAVS2030
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      BC8 = WC8 (1)+DIA*(WC8 (2)-WC8 (1))                                WAVS2040
      BSO =(WSO (1)+DIA*(WSO (2)-WSO (1)))*SALP                          WAVS2050
      BSOO=(WSOO(1)+DIA*(WSOO(2)-WSOO(1)))*SALP                          WAVS2060
      BS1 =(WS1 (1)+DIA*(WS1 (2)-WS1 (1)))*SALP                          WAVS2070
      BS2 =(WS2 (1)+DIA*(WS2 (2)-WS2 (1)))*SALP                          WAVS2080
      BS3 =(WS3 (1)+DIA*(WS3 (2)-WS3 (1)))*SALP                          WAVS2090
      BS4 =(WS4 (1)+DIA*(WS4 (2)-WS4 (1)))*SALP                          WAVS2100
      BS5 =(WS5 (1)+DIA*(WS5 (2)-WS5 (1)))*SALP                          WAVS2110
      BS6 =(WS6 (1)+DIA*(WS6 (2)-WS6 (1)))*SALP                          WAVS2120
      BS7 =(WS7 (1)+DIA*(WS7 (2)-WS7 (1)))*SALP                          WAVS2130
      BS8 =(WS8 (1)+DIA*(WS8 (2)-WS8 (1)))*SALP                          WAVS2140
C                                                                        WAVS2150
C     SHIFT MOMENT CENTER FROM XREF TO C.G.                              WAVS2160
C                                                                        WAVS2170
      BCOO = BCOO-(XS-XREF)*BCO                                          WAVS2180
      BC3  = BC3 -(XS-XREF)*BC1                                          WAVS2190
      BC4  = BC4 -(XS-XREF)*BC2                                          WAVS2200
      BC6  = BC6 -(XS-XREF)*BC5                                          WAVS2210
      BSOO = BSOO-(XS-XREF)*BSO                                          WAVS2220
      BS3  = BS3 -(XS-XREF)*BS1                                          WAVS2230
      BS4  = BS4 -(XS-XREF)*BS2                                          WAVS2240
      BS6  = BS6 -(XS-XREF)*BS5                                          WAVS2250
C                                                                        WAVS2260
C     CALCULATE WAVE FORCES AND MOMENTS                                  WAVS2270
C                                                                        WAVS2280
      FZC= BS1-XWK*G*(BS2+BSO)-U*OM1*(-A33S*CK-AL*BS2)                   WAVS2290
      FZS= BC1-XWK*G*(BC2+BCO)+U*OM1*(-A33S*SK+AL*BC2)                   WAVS2300
      FMC= BS3-XWK*G*(BS4+BSOO)-U*OM1*(-A33S*XSS*CK-BC2-AL*BS4)          WAVS2310
      FMS= BC3-XWK*G*(BC4+BCOO)+U*OM1*(-A33S*XSS*SK-BS2+AL*BC4)          WAVS2320
      FYC= XWK*G*(BC5+BCO)-U*OM1*(-A22S*SK+AL*BC5)                       WAVS2330
      FYS= -XWK*G*(BS5+BSO)-U*OM1*(-A22S*CK-AL*BS5)                      WAVS2340
      FNC= XWK*G*(BC6+BCOO)-U*OM1*(-A22S*XSS*SK-BS5+AL*BC6)              WAVS2350
      FNS= -XWK*G*(BS6+BSOO)-U*OM1*(-A22S*XSS*CK-BC5-AL*BS6)             WAVS2360
      FKC=XWK*G*(BC7-BC8)+U*OM1*(-A42S*SK+AL*BC8)                        WAVS2370
      FKS= -XWK*G*(BS7-BS8)+U*OM1*(-A42S*CK-AL*BS8)                      WAVS2380
      FZW(J)=FZW(J)-AA*(FZC*CT+FZS*ST)                                   WAVS2390
      FMW(J)=FMW(J)+AA*(FMC*CT+FMS*ST)                                   WAVS2400
      FYW(J)=FYW(J)-AA*(FYC*CT+FYS*ST)*SIGAM                             WAVS2410
      FNW(J)=FNW(J)-AA*(FNC*CT+FNS*ST)*SIGAM                             WAVS2420
      FKW(J)=FKW(J)-AA*(FKC*CT+FKS*ST)*SIGAM                             WAVS2430
      FXW(J)= FXW(J)-2.*AA*RHO*G*BS*DSS*SK*CT                            WAVS2440
   40 CONTINUE                                                           WAVS2450
      IF (IMT.EQ.2)  GO TO 100                                           WAVS2460
C                                                                        WAVS2470
C     WAVE ELEVATION AROUND THE SIDEWALLS AND SEALS                      WAVS2480
C                                                                        WAVS2490
      DO 20 J=1,4                                                        WAVS2500
      N=NSTA(J)                                                          WAVS2510
```

```
      DO 20 K=1,N                                                       WAVS2520
      ETA(J,K)=ETA(J,K)+SIN(XWK*(- XX(J,K)*COGAM-YY(J,K)*SIGAM)+FT)*AA  WAVS2530
20    CONTINUE                                                          WAVS2540
      ETACG=ETACG+AA*SIN(FT)                                            WAVS2550
      N=NSTA(3)                                                         WAVS2560
      DO 25 J=1,N                                                       WAVS2570
      ARG=AA*COS(XWK*(-XX(3,J)*COGAM)+FT)                               WAVS2580
      DETABX(J)=DETABX(J)-XWK*COGAM*ARG                                 WAVS2590
   25 CONTINUE                                                          WAVS2600
      N=NSTA(4)                                                         WAVS2610
      DO 30 J=1,N                                                       WAVS2620
      ARG=AA*COS(XWK*(-XX(4,J)*COGAM)+FT)                               WAVS2630
      DETADX(J)=DETADX(J)-XWK*COGAM*ARG                                 WAVS2640
   30 CONTINUE                                                          WAVS2650
C                                                                       WAVS2660
C     WAVE PUMPING                                                      WAVS2670
C                                                                       WAVS2680
      X1=XWK*XLBW*COGAM/2.                                              WAVS2690
      X2=XWK*XBBW*SIGAM/2.                                              WAVS2700
      FTT=FT-XWK*XCPC*COGAM                                             WAVS2710
      DVOLW=DVOLW+AA*ABW*T2(X1)*T2(X2)*SIN(FTT)                         WAVS2720
100   CONTINUE                                                          WAVS2730
      IF (IMT.EQ.2)  RETURN                                             WAVS2740
C                                                                       WAVS2750
C     TOTAL WAVE FORCES AND MOMENTS                                     WAVS2760
C                                                                       WAVS2770
      FXWAV=FXW(1)+FXW(2)                                               WAVS2780
      FYWAV=FYW(1)+FYW(2)                                               WAVS2790
      FZWAV=FZW(1)+FZW(2)                                               WAVS2800
      FKWAV=FKW(1)+FKW(2)+(FZW(2)-FZW(1))*YSW      +FYWAV*ZBAR          WAVS2810
      FMWAV=FMW(1)+FMW(2)-FXWAV*ZBAR                                    WAVS2820
      FNWAV=FNW(1)+FNW(2)+(FXW(1)-FXW(2))*YSW                           WAVS2830
      IF (IWAVES.NE.ON) RETURN                                          WAVS2840
                WRITE(6,200) ((ETA(I,J),J=1,11),I=1,4),ETACG,DVOLW      WAVS2850
     1,FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                              WAVS2860
C                                                                       WAVS2870
  200 FORMAT(/10X,5HWAVES /63H WAVE ELEVATIONS AT CRAFT STATIONS RELATIVWAVS2880
     1E TO CALM WATER (FT.) /14H PORT SIDEWALL /11F10.5/14H STBD SIDEWALWAVS2890
     2L /11F10.5/9H BOW SEAL /11F10.5/11H STERN SEAL /11F10.5/25H WAVE EWAVS2900
     3LEVATION AT C.G. = F10.5,10X,43HPLENUM VOLUME LOST DUE TO WAVES (CWAVS2910
     4U. FT.) = F15.5/10X,23HWAVES FX,FY,FZ,FK,FM,FN /6E15.4)           WAVS2920
C                                                                       WAVS2930
      RETURN                                                            WAVS2940
      END                                                               WAVS2950

C                                                                       SHX 0010
      FUNCTION SHXYAX (X,Z,ANGYAX,PI)                                   SHX 0020
```

```
C
      H=SQRT(X**2+Z**2)
      IF(X.EQ.0.0) GO TO 1
      ARG=Z/X
      ANGOLD=ATAN(ARG)
      IF(ANGOLD.GE.0.0) GO TO 2
      ANGNEW=ANGOLD+PI-ANGYAX
      GO TO 3
    1 ANGNEW=PI/2.0-ANGYAX
      GO TO 3
    2 ANGNEW=ANGOLD-ANGYAX
    3 SHXYAX=H*COS(ANGNEW)
C
      RETURN
      END


C
C    SIDETAB PROGRAM FOR COMPUTING SIDEWALL TABLE OF FORCES AND MOMENTS
C
      DIMENSION FC1(95),FC2(95),FC3(95),FC4(95),FC5(95),FC6(95),FC7(95)
     1          ,FC0(95),FC00(95),FC8(95)
      DIMENSION FS1(95),FS2(95),FS3(95),FS4(95),FS5(95),FS6(95),FS7(95)
     1          ,FS0(95),FS00(95),FS8(95)
      DIMENSION Z(14050),XIN(10)
      COMMON /ATAB/ NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,
     1          AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),
     2          AC5(20,5,7),AC6(20,5,7),AC7(20,5,7)
     3          ,AC0(20,5,7),AC00(20,5,7),AC8(20,5,7),
     4          AS1(20,5,7),AS2(20,5,7),AS3(20,5,7),AS4(20,5,7),
     5          AS5(20,5,7),AS6(20,5,7),AS7(20,5,7)
     6          ,AS0(20,5,7),AS00(20,5,7),AS8(20,5,7),BB(36),XREF,RX
      EQUIVALENCE (Z,NAL)
      COMMON    XX(95),ZZ(8,95),YY(8,95),XXX
      DATA G,RHO/32.2,2./
      NAMELIST/INPUT/NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,
     1  NSTA,ND,DRMAX,XREF,NIN,XIN
C     THIS PROGRAM EVALUATES INTEGRALS THAT ARE NECESSARY FOR THE EVALUA
C     THE HYDROSTATIC AND HYDRODYNAMIC FORCES AND MOMENTS FOR A SINGLE S
C     AS A FUNCTION OF DRAFT,TRIM AND WAVELENGTH.
C     DECK SET UP FOR XR-3 CRAFT - 19 JULY 1973
C
C     READ INTEGRAL TABLE PARAMETERS
C
      RX=0.0
      READ(5,990) NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB
C     READ NO. OF STATIONS AND MAX. NO. OF DRAFTS/STATIONS
      READ(5,991) NSTA,ND
```

```
C     READ MAX. DRAFT                                                   SWTB0320
      READ(5,900) DRMAX                                                 SWTB0330
                                                                        SWTB0340
C     READ REFERENCE POSITION + INTEGRAL LIMITS (DISTANCES FROM TRANSOM)SWTB0350
      READ  (5,906) XREF                                                SWTB0360
      READ  (5,907) NIN,( XIN(I),I=1,NIN)                               SWTB0370
      IF ( NIN.GT.10 )  GO TO 211                                       SWTB0380
      WRITE(6,INPUT)                                                    SWTB0390
      IF (SAL .NE. 0.) GOTO 212                                         SWTB0400
      PI=4.*ATAN(1.)                                                    SWTB0410
      RAD =180./PI                                                      SWTB0420
      WRITE (6,999)                                                     SWTB0430
C                                                                       SWTB0440
C     READ OFFSET DATA (BOW TO STERN)                                   SWTB0450
C     XX IS LONGITUDINAL DISTANCE OF STATION FROM BOW - INCHES          SWTB0460
C     YY IS LOCAL WATERLINE BEAM - FEET                                 SWTB0470
C     ZZ IS CORRESPONDING HEIGHT OF LOCAL BEAM - FEET                   SWTB0480
C                                                                       SWTB0490
      DO 40 J=1,NSTA                                                    SWTB0500
      READ(5,900) XX(J),((ZZ(I,J),YY(I,J)),I=1,ND)                      SWTB0510
      JJ=J-1                                                            SWTB0520
      WRITE(6,903) JJ,XX(J),((ZZ(I,J),YY(I,J)),I=1,ND)                  SWTB0530
40    CONTINUE                                                          SWTB0540
C     CCNVERT XX(INCHES) TO XX(FEET)                                    SWTB0550
      DO 41 J=1,NSTA                                                    SWTB0560
41    XX(J) =XX(J)/12.                                                  SWTB0570
      XRAF = XX(NSTA)-XREF                                              SWTB0580
                                                                        SWTB0590
C                                                                       SWTB0600
C     GENERATE TABLES FOR SIDEWALLS AND WAVES                           SWTB0610
C                                                                       SWTB0620
      MSTA=NSTA                                                         SWTB0630
      NINI = NIN+1                                                      SWTB0640
      DO 101 IN=1,NINI                                                  SWTB0650
      NSTA = MSTA                                                       SWTB0660
      IF (IN.EQ.1)  GO TO 48                                            SWTB0670
      XXX = XX(MSTA)-XIN(IN-1)                                          SWTB0680
      GO TO 49                                                          SWTB0690
   48 XXX = XX(MSTA)                                                    SWTB0700
   49 XINT = XRAF-XXX                                                   SWTB0710
      DO 100 IA=1,NAL                                                   SWTB0720
      AL = SAL+DAL*(IA-1)                                               SWTB0730
      DO 100 ID=1,NDS                                                   SWTB0740
      DS =(SDS+DDS*(ID-1))/12.0                                         SWTB0750
      DO 100 IP=1,NTH                                                   SWTB0760
      TH =(STH+DTH*(IP-1))/RAD                                          SWTB0770
      DO 80 J=1,NSTA                                                    SWTB0780
      JJ=J-1                                                            SWTB0790
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```
      X=XRAF-XX(J)                                                      SWTB0800
      IF ( X.LE.XINT )  NSTA = J                                        SWTB0810
      DX=DS-TH*X                                                        SWTB0820
      IF (DX .GT. DRMAX)  DX = DRMAX                                    SWTB0830
      IF(DX) 50,50,60                                                   SWTB0840
   50 DX=0.                                                             SWTB0850
      B=0.                                                              SWTB0860
      S=0.                                                              SWTB0870
      ZB=0.0                                                            SWTB0880
      A33=0.                                                            SWTB0890
      A22=0.                                                            SWTB0900
      A42=0.                                                            SWTB0910
      GOTO 70                                                           SWTB0920
   60 CONTINUE                                                          SWTB0930
C                                                                       SWTB0940
C     CALCULATE AREA + CENTER OF BUOYANCY (IF DX .GT. 0)                SWTB0950
C                                                                       SWTB0960
      S=0.                                                              SWTB0970
      DSZ=0.                                                            SWTB0980
      I=1                                                               SWTB0990
105   Z1=ZZ(I,J)                                                        SWTB1000
      Z2=ZZ(I+1,J)                                                      SWTB1010
      Y1=YY(I,J)                                                        SWTB1020
      Y2=YY(I+1,J)                                                      SWTB1030
      K=1                                                               SWTB1040
      DZ=Z2-Z1                                                          SWTB1050
      IF(DZ .EQ. 0.) GO TO 50                                           SWTB1060
      IF(DX-Z1 .LE. 0.) GO TO 50                                        SWTB1070
      IF(DX-Z2 .LE. 0.) GOTO 120                                        SWTB1080
110   CONTINUE                                                          SWTB1090
      S=S+DZ*(Y1+Y2)/2.                                                 SWTB1100
      SPIN=(Y2-Y1)/DZ                                                   SWTB1110
      BX=(Y1*Z2-Z1*Y2)/DZ                                               SWTB1120
      DSZ0=BX*(Z2*Z2-Z1*Z1)/2. +SPIN*(Z2*Z2*Z2-Z1*Z1*Z1)/3.             SWTB1130
      DSZ=DSZ+DSZ0                                                      SWTB1140
      I=I+1                                                             SWTB1150
      GO TO (105,130),K                                                 SWTB1160
120   K=2                                                               SWTB1170
      Y2=Y1+(DX-Z1)*(Y2-Y1)/DZ                                          SWTB1180
      Z2=DX                                                             SWTB1190
      DZ=Z2-Z1                                                          SWTB1200
      GOTO 110                                                          SWTB1210
130   CONTINUE                                                          SWTB1220
      ZB=DX-DSZ/S                                                       SWTB1230
      DX = DX-ZZ(1,J)                                                   SWTB1240
      B=Y2                                                              SWTB1250
      A33=(RHO*PI*B**2)/8.                                              SWTB1260
      A22=(RHO*.4*PI*DX**2)/2.                                          SWTB1270
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      A42=(RHO*PI*DX**3)/4.                                             SWTB1280
   70 CONTINUE                                                          SWTB1290
      F0=S                                                              SWTB1300
      F00=F0*X                                                          SWTB1310
      F1=B                                                              SWTB1320
      F2=A33                                                            SWTB1330
      F3=F1*X                                                           SWTB1340
      F4=F2*X                                                           SWTB1350
      F5=A22                                                            SWTB1360
      F6=F5*X                                                           SWTB1370
      F7=B**3/12.-S*ZB                                                  SWTB1380
      F8=A42                                                            SWTB1390
      CAX=COS(-AL*X)                                                    SWTB1400
      SAX=SIN(-AL*X)                                                    SWTB1410
      IX=J                                                              SWTB1420
      FC0(IX)=F0*CAX                                                    SWTB1430
      FC00(IX)=F00*CAX                                                  SWTB1440
      FC1(IX)=F1*CAX                                                    SWTB1450
      FC2(IX)=F2*CAX                                                    SWTB1460
      FC3(IX)=F3*CAX                                                    SWTB1470
      FC4(IX)=F4*CAX                                                    SWTB1480
      FC5(IX)=F5*CAX                                                    SWTB1490
      FC6(IX)=F6*CAX                                                    SWTB1500
      FC7(IX)=F7*CAX                                                    SWTB1510
      FC8(IX)=F8*CAX                                                    SWTB1520
      FS0(IX)=F0*SAX                                                    SWTB1530
      FS00(IX)=F00*SAX                                                  SWTB1540
      FS1(IX)=F1*SAX                                                    SWTB1550
      FS2(IX)=F2*SAX                                                    SWTB1560
      FS3(IX)=F3*SAX                                                    SWTB1570
      FS4(IX)=F4*SAX                                                    SWTB1580
      FS5(IX)=F5*SAX                                                    SWTB1590
      FS6(IX)=F6*SAX                                                    SWTB1600
      FS7(IX)=F7*SAX                                                    SWTB1610
      FS8(IX)=F8*SAX                                                    SWTB1620
   80 CONTINUE                                                          SWTB1630
      AC0(IA,ID,IP)=TRAP(FC0,NSTA)*RHO                                  SWTB1640
      AC00(IA,ID,IP)=TRAP(FC00,NSTA)*RHO                                SWTB1650
      AC1(IA,ID,IP)=TRAP(FC1,NSTA)*RHO*G                                SWTB1660
      AC2(IA,ID,IP)=TRAP(FC2,NSTA)                                      SWTB1670
      AC3(IA,ID,IP)=TRAP(FC3,NSTA)*RHO*G                                SWTB1680
      AC4(IA,ID,IP)=TRAP(FC4,NSTA)                                      SWTB1690
      AC5(IA,ID,IP)=TRAP(FC5,NSTA)                                      SWTB1700
      AC6(IA,ID,IP)=TRAP(FC6,NSTA)                                      SWTB1710
      AC7(IA,ID,IP)=TRAP(FC7,NSTA)*RHO                                  SWTB1720
      AC8(IA,ID,IP)=TRAP(FC8,NSTA)                                      SWTB1730
      AS0(IA,ID,IP)=TRAP(FS0,NSTA)*RHO                                  SWTB1740
      AS00(IA,ID,IP)=TRAP(FS00,NSTA)*RHO                                SWTB1750
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      AS1(IA,ID,IP)=TRAP(FS1,NSTA)*RHO*G                                SWTB1760
      AS2(IA,ID,IP)=TRAP(FS2,NSTA)                                      SWTB1770
      AS3(IA,ID,IP)=TRAP(FS3,NSTA)*RHO*G                                SWTB1780
      AS4(IA,ID,IP)=TRAP(FS4,NSTA)                                      SWTB1790
      AS5(IA,ID,IP)=TRAP(FS5,NSTA)                                      SWTB1800
      AS6(IA,ID,IP)=TRAP(FS6,NSTA)                                      SWTB1810
      AS7(IA,ID,IP)=TRAP(FS7,NSTA)*RHO                                  SWTB1820
      AS8(IA,ID,IP)=TRAP(FS8,NSTA)                                      SWTB1830
  100 CONTINUE                                                          SWTB1840
C                                                                       SWTB1850
C     CALCULATE TABLE OF OFFSETS FOR STATION AT INTEGRATION LIMIT       SWTB1860
      J = NSTA                                                          SWTB1870
      DO 90 II=1,NBB                                                    SWTB1880
      DX = SBB+DBB*(II-1)                                               SWTB1890
      I = 1                                                             SWTB1900
   89 Z1=ZZ(I,J)                                                        SWTB1910
      Z2=ZZ(I+1,J)                                                      SWTB1920
      DZ=Z2-Z1                                                          SWTB1930
      IF (DZ.EQ.0.0)  GO TO 91                                          SWTB1940
      IF (DX.LT.Z1)  GO TO 91                                           SWTB1950
      IF (DX.GE.Z2)  GO TO 92                                           SWTB1960
      Y1=YY(I,J)                                                        SWTB1970
      Y2=YY(I+1,J)                                                      SWTB1980
      BB(II)=Y1+(DX-Z1)*(Y2-Y1)/DZ                                      SWTB1990
      GO TO 90                                                          SWTB2000
   92 I = I+1                                                           SWTB2010
      GO TO 89                                                          SWTB2020
   91 BB(II) = 0.0                                                      SWTB2030
   90 CONTINUE                                                          SWTB2040
      INTA = IN+9                                                       SWTB2050
      IF(INTA.GT.10) GO TO 65                                           SWTB2060
      WRITE ( INTA )  Z                                                 SWTB2070
   65 CONTINUE                                                          SWTB2080
      WRITE(6,940) XXX                                                  SWTB2090
      DO 93 I=1,NBB                                                     SWTB2100
      DRAFT =SBB+(I-1)*DBB                                              SWTB2110
 93   WRITE(6,941) DRAFT,BB(I)                                          SWTB2120
      DO 200 ID=1,3                                                     SWTB2130
      DS = SDS+DDS*(ID-1)                                               SWTB2140
      WRITE (6,950) DS                                                  SWTB2150
      DO 200 IP=1,3                                                     SWTB2160
      TH = STH+DTH*(IP-1)                                               SWTB2170
      WRITE (6,960) TH                                                  SWTB2180
      DO 200 IA=1,3                                                     SWTB2190
      AL = SAL+DAL*(IA-1)                                               SWTB2200
      WRITE (6,921) AL                                                  SWTB2210
      WRITE (6,920) ACO(IA,ID,IP),ACOO(IA,ID,IP),AC1(IA,ID,IP),         SWTB2220
     1 AC2(IA,ID,IP),AC3(IA,ID,IP),AC4(IA,ID,IP),AC5(IA,ID,IP),         SWTB2230
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      2 AC6(IA,ID,IP),AC7(IA,ID,IP),AC8(IA,ID,IP)                       SWTB2240
        WRITE (6,920) AS0(IA,ID,IP),AS00(IA,ID,IP),AS1(IA,ID,IP),       SWTB2250
      1 AS2(IA,ID,IP),AS3(IA,ID,IP),AS4(IA,ID,IP),AS5(IA,ID,IP),        SWTB2260
      2 AS6(IA,ID,IP),AS7(IA,ID,IP),AS8(IA,ID,IP)                        SWTB2270
200     CONTINUE                                                         SWTB2280
  101 CONTINUE                                                           SWTB2290
C                                                                        SWTB2300
  201 STOP                                                               SWTB2310
C                                                                        SWTB2320
  210 WRITE (6,923)                                                      SWTB2330
      GO TO 201                                                          SWTB2340
  211 WRITE (6,924)                                                      SWTB2350
      GO TO 201                                                          SWTB2360
 212  WRITE(6,925)                                                       SWTB2370
      GOTO 201                                                           SWTB2380
C                                                                        SWTB2390
900   FORMAT( 15E5.0)                                                    SWTB2400
903   FORMAT (12H STATION NO. ,I2,1X,F6.2, /17X,12(F7.3    ),            SWTB2410
     1        /17X,12(F7.3    ))                                         SWTB2420
  906 FORMAT ( F16.2 )                                                   SWTB2430
907   FORMAT(I5,10E5.0)                                                  SWTB2440
920   FORMAT (1X,10E12.4)                                                SWTB2450
921   FORMAT(/ 13H 2PI/LAMBDA     F8.4)                                  SWTB2460
923   FORMAT(// 35H LOCAL DRAFT OUT OF RANGE OF TABLES )                 SWTB2470
  924 FORMAT ( // 27H  TOO MANY INTEGRAL LIMITS. )                       SWTB2480
 925  FORMAT(43H THE FIRST VALUE OF 2PI/LAMBDA MUST BE ZERO)             SWTB2490
  940 FORMAT ( 1H1, 10(/), 39H  INTEGRALS FROM BOW, OVER A LENGTH OF  ,  SWTB2500
     X F7.3,/,23H    DRAFT        OFFSET )                               SWTB2510
 941  FORMAT(F7.3,5X,F7.3)                                               SWTB2520
950   FORMAT (1H1,14H DRAFT(INCHES)  F4.1)                               SWTB2530
960   FORMAT (//,13H THETA(DEG)     F4.1)                                SWTB2540
 990  FORMAT(4(I5,2F5.0))                                                SWTB2550
 991  FORMAT(2I5)                                                        SWTB2560
997   FORMAT(/ )                                                         SWTB2570
 999  FORMAT( 1H1,40X,23H XR-3 SIDEWALL PROGRAM  ///)                    SWTB2580
C                                                                        SWTB2590
      END                                                                SWTB2600
C                                                                        SWTB2610
      FUNCTION TRAP(Y,N)                                                 SWTB2620
C                                                                        SWTB2630
      COMMON    XX(95),ZZ(8,95),YY(8,95),XXX                             SWTB2640
      DIMENSION Y(1)                                                     SWTB2650
C                                                                        SWTB2660
      N1 = N-2                                                           SWTB2670
      TRAP=0.0                                                           SWTB2680
      DO 10 I=1,N1                                                       SWTB2690
10    TRAP=TRAP+ .5*(XX(I+1)-XX(I))*(Y(I+1)+Y(I))                        SWTB2700
      N1=N-1                                                             SWTB2710
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      YN = Y(N1)+(XXX-XX(N1))*(Y(N1+1)-Y(N1))/(XX(N1+1)-XX(N1))         SWTB2720
      TRAP = TRAP+0.5*(XXX-XX(N1))*(YN+Y(N1))                            SWTB2730
      RETURN                                                             SWTB2740
      END                                                                SWTB2750
  20  0.1  0.0    5  5.0  2.0    7  1.0 -3.0   31 0.06  0.0
  29    7
 1.84
  9.0
   55.0  7.5  10.0 12.5 15.0
  3.02.250 0.0   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  9.62.C80  0.02.2500.416  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 13.61.670  0.01.8300.3582.0800.4752.2500.540  0.0  0.0  0.0  0.0  0.0  0.0
 17.61.220  0.01.4200.3251.8400.4832.2500.616  0.0  0.0  0.0  0.0  0.0  0.0
 21.60.791  0.01.2200.3581.6660.5251.8350.5842.0800.6582.2500.717  0.0  0.0
 25.60.3410.1170.5830.2171.0000.3841.4200.5401.8400.6662.2500.770  0.0  0.0
 29.6  0.00.1160.3500.2250.7910.3921.2250.5671.6660.7082.0800.8172.2500.868
 33.6  C.00.1170.1660.2290.5830.4831.0000.6821.4200.8351.8400.8952.2501.000
 41.6  0.00.1170.1660.2500.5830.5351.0000.7251.4200.8951.8401.0002.2501.060
 49.6  0.00.1170.1660.2540.5830.5451.0000.7681.4200.9211.8401.0202.2501.080
 57.6  0.00.1170.1660.2540.5830.5451.0000.7681.4200.9211.8401.0202.2501.080
137.6  C.00.1170.1660.2540.5830.5451.0000.7681.4200.9211.8401.0202.2501.080
145.6  0.00.1660.1660.2830.5830.5661.0000.7771.4200.9251.8401.0352.2501.082
153.6  0.00.2090.1660.3180.5830.5841.0000.7871.4200.9321.8401.0352.2501.082
161.6  0.00.2500.1660.3500.5830.6081.0000.8001.4200.9381.8401.0352.2501.082
169.6  0.00.2840.1660.3830.5830.6251.0000.8131.4200.9451.8401.0352.2501.086
177.6  0.00.3250.1650.4160.5830.6501.0000.8251.4200.9551.8401.0352.2501.091
185.6  0.00.3670.1660.4510.5830.6751.0000.8371.4200.9601.8401.0402.2501.091
193.6  0.00.4080.1660.4910.5830.6921.0000.8501.4200.9701.8401.0502.2501.091
201.6  C.00.4420.1660.5250.5830.7101.0000.8621.4200.9721.8401.0502.2501.091
209.6  0.00.4820.1660.5590.5830.7331.0000.8751.4200.9781.8401.0502.2501.091
217.6  C.00.5250.1660.5910.5830.7601.0000.8881.4200.9861.8401.0582.2501.091
225.6  0.00.5580.1660.6250.5830.7741.0000.9001.4200.9951.8401.0582.2501.091
233.6  C.00.5910.1660.6560.5830.8001.0000.9151.4201.0001.8401.0582.2501.091
241.6  0.00.6250.1660.6910.5830.8251.0000.9301.4201.0101.8401.0682.2501.091
249.6  0.00.6650.1660.7250.5830.8501.0000.9421.4201.0201.8401.0662.2501.091
257.6  0.00.7160.1660.7590.5830.8851.0000.9571.4201.0251.8401.0662.2501.091
265.6  0.00.7580.1660.8000.5830.8931.0000.9751.4201.0321.5151.0662.2501.066
273.6  0.00.8000.1660.8340.5830.9161.0000.9931.4201.0411.5151.0662.2501.066
C                                                                        PROP0010
      SUBROUTINE PROP                                                    PROP0020
C                                                                        PROP0030
      INTEGER ON                                                         PROP0040
      COMMON /CONST/ PI,RAD,UO                                           PROP0050
      COMMON /FPROP/ FX,FY,FZ,FK,FM,FN                                   PROP0060
      COMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,      PROP0070
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      ATIF(25),TIS(25)                                                   PROP0080
       COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  PROP0090
      -IRUD,IPROP,IAEROD,IRHS                                            PROP0100
       COMMON /PROMOD/  PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7 PROP0110
       COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,  PROP0120
      ARCLB,RTC,RUDANG,TIR(25)                                           PROP0130
       COMMON /VARBLE/ VAL(40)                                           PROP0140
       EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),       PROP0150
      1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     PROP0160
      2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),PROP0170
      3(VAL(24),PB)                                                      PROP0180
       DIMENSION THS(1),THP(1),TS(1),TP(1),RUD(1),TR(1)                  PROP0190
       EQUIVALENCE (THSTS(1),THS(1)),(THSTP(1),THP(1)),(TIS(1),TS(1)),(TIPROP0200
      AP(1),TP(1)),(TIR(1),TR(1)),(DELRUD(1),RUD(1))                     PROP0210
C                                                                        PROP0220
       FX = 0.0                                                          PROP0230
       FY = 0.0                                                          PROP0240
       FZ = 0.0                                                          PROP0250
       FK = 0.0                                                          PROP0260
       FM = 0.0                                                          PROP0270
       FN = 0.0                                                          PROP0280
       TL=TIME                                                           PROP0290
       IF(NPR.EQ.0.0) GO TO 5                                            PROP0300
       RUDANG=FG1(TL,NPR,TR,RUD,IR)                                      PROP0310
       RUDANG=RUDANG/RAD                                                 PROP0320
C                                                                        PROP0330
C     CALCULATE THRUSTS AND MOMENTS INDIVIDUALLY                         PROP0340
C                                                                        PROP0350
       GO TO 6                                                           PROP0360
     5 RUDANG=DELRUD(1)                                                  PROP0370
       RUDANG=RUDANG/RAD                                                 PROP0380
     6 CD=COS(RUDANG)                                                    PROP0390
       SD=SIN(RUDANG)                                                    PROP0400
       IF(NPS.EQ.0.0) GO TO 2                                            PROP0410
       THSS=FG1(TL,NPS,TS,THS,IS)                                        PROP0420
       GO TO 4                                                           PROP0430
     2 THSS=THSTS(1)                                                     PROP0440
     4 IF(NPP.EQ.0.0) GO TO 3                                            PROP0450
       THSP=FG1(TL,NPP,TP,THP,IP)                                        PROP0460
       GO TO 1                                                           PROP0470
     3 THSP=THSTP(1)                                                     PROP0480
     1 STHSTS=STHS*THSS                                                  PROP0490
       STHSTP=STHP*THSP                                                  PROP0500
       FXS=THSS*CD-STHSTS*SD                                             PROP0510
       FXP=THSP*CD+STHSTP*SD                                             PROP0520
       FYS=-STHSTS*CD-THSS*SD                                            PROP0530
       FYP=STHSTP*CD+SD*THSP                                             PROP0540
       FZS=-THSS*THETA*CD+STHSTS*SD*PHI                                  PROP0550
```

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      FZP=-THSP*THETA*CD-STHSTP*SD*PHI                                  PROP0560
      FX=FXP+FXS                                                        PROP0570
      FY=FYP+FYS                                                        PROP0580
      FZ=FZP+FZS                                                        PROP0590
      FKP=-FZP*YP-FYP*ZP                                                PROP0600
      FKS=FZS*YP-FYS*ZP                                                 PROP0610
      FK=FKS+FKP                                                        PROP0620
      FMS=FZS*(-XP)+FXS*ZP                                              PROP0630
      FMP=FZP*(-XP)+FXP*ZP                                              PROP0640
      FM=FMS+FMP                                                        PROP0650
      FNS=-FXS*YP-FYS*(-XP)                                             PROP0660
      FNP=FXP*YP-FYP*(-XP)                                              PROP0670
      FN=FNS+FNP                                                        PROP0680
      IF (IPROP.NE.ON) RETURN                                           PROP0690
                   WRITE(6,123)                                         PROP0700
     1FX,FY,FZ,FK,FM,FN                                                 PROP0710
  123 FORMAT(/10X,22HPROP FX,FY,FZ,FK,FM,FN  /6E15.4)                   PROP0720
      RETURN                                                            PROP0730
      END                                                               PROP0740

C                                                                       FG1 0010
      FUNCTION FG1(X,N,XT,YT,IX)                                        FG1 0020
C                                                                       FG1 0030
      DIMENSION XT(1),YT(1)                                             FG1 0040
C                                                                       FG1 0050
      IF (IX.LT.1) IX=1                                                 FG1 0060
      IF (IX.GT.N-1) IX=N-1                                             FG1 0070
      I=SIGN(1.0,X-XT(IX))                                              FG1 0080
 10   IF (IX.LT.1 .OR. IX.GE.N) GO TO 30                                FG1 0090
      IF (XT(IX).GT.X .OR. X.GT.XT(IX+1)) GO TO 20                      FG1 0100
      C=(X-XT(IX))/(XT(IX+1)-XT(IX))                                    FG1 0110
      GO TO 100                                                         FG1 0120
 20   IX=IX+I                                                           FG1 0130
      GO TO 10                                                          FG1 0140
 30   C=IX/N                                                            FG1 0150
      IX=IX-I                                                           FG1 0160
 100  FG1=YT(IX)+C*(YT(IX+1)-YT(IX))                                    FG1 0170
      RETURN                                                            FG1 0180
      END                                                               FG1 0190

C                                                                       RUD 0010
      SUBROUTINE RUDDER                                                 RUD 0020
C                                                                       RUD 0030
      INTEGER ON                                                        RUD 0040
      COMMON /CONST/ PI,RAD,UO                                          RUD 0050
      COMMON /FRUD/ FX,FY,FZ,FK,FM,FN                                   RUD 0060
```

```
      COMMON /MASSES/  AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,
     -                 AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO
      COMMON /PROMOD/  PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,
     -IRUD,IPROP,IAEROD,IRHS
      COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,
     ARCLB,RTC,RUDANG,TIR(25)
      COMMON /VARBLE/ VAL(40)
      EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),
     3(VAL(24),PB)
      EQUIVALENCE (DELRUD(1),RUD(1)),(TIR(1),TR(1))
      DIMENSION RUD(1),TR(1)
      EQUIVALENCE (VAL(18),FANPWR)
      DATA ENU /1.28E-5/
C
C     CALCULATE PROGRAMMED RUDDER DEFLECTION
C
      TL=TIME
      IF(NPR.EQ.0.0) GO TO 5
      GO TO 6
    5 RUDANG=DELRUD(1)
      RUDANG=RUDANG/RAD
      GO TO 7
    6 RUDANG=FG1(TL,NPR,TR,RUD,IR)
      RUDANG=RUDANG/RAD
C
C     SIDE FORCE ON RUDDER
C
    7 DSR=Z+ZS-XR*THETA
      ENDFAC=(1.+DSR/(DSR+RSPAN))
      VH=V+XR*R-ZR*P
      QQ=HRHO*U*U*RAREA
      EFFANG=RUDANG-ENDFAC*VH/U
      FY=2.*QQ*ENDFAC*RCLB*EFFANG
C
C     DRAG FORCE ON RUDDER
C
      REY=U*(RAREA/RSPAN)/ENU
      CFR=.427/(ALOG10(REY)-.407)**2.64
      PI8=PI/8.
      CD=2.*CFR+ PI8*RTC*RTC*(1.+G*RSPAN/(U*U))+RCLB*EFFANG*EFFANG
      FX=-2.*CD*RAREA*HRHO*U*U
      FZ=0.
      FK=-ZR*FY
      FM=FX*ZR
      FN=XR*FY
```

```
      IF(IRUD.NE.ON) RETURN
                    WRITE(6,123)
     1FX,FY,FZ,FK,FM,FN
C
  123 FORMAT(/10X,24HRUDDER FX,FY,FZ,FK,FM,FN /6E15.4)
C
      RETURN
      END


C
      SUBROUTINE AEROD
C

      INTEGER ON
      COMMON /FAERO/ FX,FY,FZ,FK,FM,FN
      COMMON /FAIR/ RHOA,XLAERO
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,
     -IRUD,IPROP,IAEROD,IRHS
      COMMON /VARBLE/ VAL(40)
      EQUIVALENCE             (VAL(2),U),(VAL(3),V),(VAL(4),W),
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),
     3(VAL(24),PB)
C
      QA=RHOA*U*U
      QAL=QA*XLAERO
      BETA=-V/U
      BETASQ=BETA*BETA
      FX=-(0.90*BETASQ+0.13)*QA
      FY=(0.0*BETASQ+0.53*BETA)*QA
      FZ=-(2.06*BETASQ+0.39)*QA
      FK=-(0.5*BETASQ+0.0*BETA)*QAL
      FM=(0.29*BETASQ+0.12)*QAL
      FN=(0.0*BETASQ+0.076*BETA)*QAL
      IF (IAEROD.NE.ON) RETURN
                    WRITE(6,100) FX,FY,FZ,FK,FM,FN
C
  100 FORMAT(/10X,23HAEROD FX,FY,FZ,FK,FM,FN/6E15.4)
C
      RETURN
      END


C
      SUBROUTINE INTGRL (TIME)
C
```

```
      INTEGER ON
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IY
      COMMON /EQNCO/ NEQS,TOL(20),JQQ
      COMMON /KSWTCH/ ITHRST
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,
     -                 AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO
      COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,
     -IRUP,IPROP,IAEROD,IRHS
      COMMON /STABLE/ S(4),ISTAB
      COMMON/STEP/STEP2
      COMMON / VALOLD / YOLD(20)
      COMMON /VARBLE/ VAL(40)
      EQUIVALENCE (VAL(1),X),(VAL(2),Y(1))
      DIMENSION Y(20),ERROR(20)
      REAL K1(20),K2(20),K3(20),K4(20),K5(20)
      DATA IPASS/0/
C
      STEP2=1.0
      PB=VAL(24)
      BMASS=Y(10)
    1 IF((TIME+DELT).LE.TPRINT) GO TO 12
      DEL=DELT
      DELT=TPRINT-TIME
      IPASS=1
   12 X=TIME
      DO 2 J=1,NEQS
      Y(J)=YOLD(J)
    2 CONTINUE
      ITHRST=1
C
      CALL RHS(K1)
C
      ITHRST=2
      IMT = 0
      IF (IACCEL.NE. ON) GO TO 14
      ACCLAT = (K1(2)+Y(1)*Y(6))/G
      WRITE  (6,101)  ACCLAT , DELT
 14   ON=2
  15  H=DELT/3.
      X=TIME+H
      DO 3 J=1,NEQS
    3 Y(J)=YOLD(J)+H*K1(J)
C
      CALL RHS(K2)
C
      DO 4 J=1,NEQS
```

```
    4 Y(J)=YCLD(J)+.5*H*(K1(J)+K2(J))
C
      CALL RHS(K3)
C
      X=TIME+.5*DELT
      DO 5 J=1,NEQS
    5 Y(J)=YCLD(J)+.375*H*(K1(J)+3.*K3(J))
C
      CALL RHS(K4)
C
      X=TIME+DELT
      DC 6 J=1,NEQS
    6 Y(J)=YCLD(J)+.5*H*(3.*K1(J)-9.*K3(J)+12.*K4(J))
C
      CALL RHS(K5)
C
      IF (JQQ.EQ. 1 ) GO TO 7
      DO 7 J=1,NEQS
      ERROR(J)=(K1(J)-4.5*K3(J)+4.*K4(J)-.5*K5(J))*H/5.0
      IF(ABS(ERROR(J)).GT.TOL(J)) GO TO 11
    7 CONTINUE
      DO 105 J=1,NEQS
      Y(J)=YCLD(J)+.5*H*(K1(J)+4.*K4(J)+K5(J))
  105 YCLD(J)=Y(J)
      TIME=TIME+DELT
      IF (IPASS.EQ.1) GO TO 8
      IF (JQQ.EQ. 1 ) GO TO 10
      DO 75 J=1,NEQS
      IF(ABS(ERROR(J)).GT.TOL(J)/16.) GO TO 9
   75 CONTINUE
      DELT=2.*DELT
      IF (DELT.GT.DELPNT) DELT=DELPNT
C
   10 RETURN
C
    9 STEP2=DELT
      GO TO 10
    8 DELT=DEL
      IPASS=0
      GC TO 10
   11 DELT=DELT/2.
      IF (DELT.LT. 1.E-6 )  GC TO 25
      IF(JQQ.EQ.2) GO TO 26
                      WRITE (6,666) TIME,DELT,J,ERROR(J),TOL(J)
   27 IPASS=0
      GC TO 15
   26 STEP1=DELT*2.0
      IF(STEP1.LT.STEP2)STEP2=STEP1
```

```
      GO TO 27                                                          INT 1000
   25 WRITE ( 6,150 )                                                   INT 1010
      WRITE (6,100) TIME,DELT,(K1(J),J=1,NEQS),VAL                      INT 1020
      STCP                                                              INT 1030
C                                                                       INT 1040
  100 FCRMAT(/10X,23HINTGRL TIME,DELT,K1,VAL /2E15.4/2(5E15.4/),5(8E15.4INT 1050
     1/))                                                               INT 1060
  101 FCRMAT(1H0,9X,33HTOTAL LATERAL ACCELERATION (G) =    F12.4,       INT 1070
     112X,5HDT =  E15.4)                                                INT 1080
  150 FCRMAT(1H1,10X,44HDELTA TIME LESS THAN 1.0E-6  -   -  JOB STOPS ) INT 1090
  666 FCRMAT(/10X,5HINT-J 2E30.5,I5,2E20.5)                             INT 1100
      END                                                               INT 1110


C                                                                       RHS 0010
      SUBROUTINE RHS(VALUE)                                             RHS 0020
C                                                                       RHS 0030
      INTEGER ON                                                        RHS 0040
      COMMON /AIR/ PINF,RHOINF,GAM                                      RHS 0050
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYRHS 0060
      COMMON /COLUMN/ IVERT,ILATRL                                      RHS 0070
      CCMMON /CONST/ PI,RAD,UO                                          RHS 0080
      CCMMON /CNTRL/CONTW,CONTQ,CONTTH,QMULT,LOUVER,ACONTZ,ACONTW,ZEQUILRHS 0090
     1 ,THEQL,ACBASE                                                    RHS 0100
      CCMMON/ENGINE/NPS,NPP,THSTS(25),THSTP(25),XP,YP,ZP,STHS,STHP,     RHS 0110
     ATIP(25),TIS(25)                                                   RHS 0120
      COMMON /FANMAP/QIN,QBFAN(25),QMFAN(25),QSFAN(25),ENBFAN,ENMFAN,   RHS 0130
     1 ENSFAN,BRPM,MRPM,SRPM,NPTSB,NPTSM,NPTSS                          RHS 0140
     2 ,PBFAN(25),PMFAN(25),PSFAN(25),TMEB(25),DELB(25),NB,TMES(25),    RHS 0150
     3DETS(25),NS                                                       RHS 0160
      COMMON /FAERO/ FXAED,FYAED,FZAED,FKAED,FMAED,FNAED                RHS 0170
      COMMON /FORBS/FXBS,FYBS,FZBS,FKBS,FMBS,FNBS,QLBS                  RHS 0180
      COMMON /FORSS/FXSS,FYSS,FZSS,FKSS,FMSS,FNSS,QLSS,FMS              RHS 0190
      CCMMON /FPROP/ FXP,FYP,FZP,FKP,FMP,FNP                            RHS 0200
      COMMON / FROUDE / FN,FNCRIT                                       RHS 0210
      COMMON /FRUD/ FXRUD,FYRUD,FZRUD,FKRUD,FMRUD,FNRUD                 RHS 0220
      COMMCN/GBOW/ XBOW                                                 RHS 0230
      COMMON /GEOM/    WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM     RHS 0240
     1,DELS(4,10),XCP,ZCP                                               RHS 0250
      CCMMON /GEOMBS/DETABX(11),DETABT(11),ARM1B(10),ARM2B(10)          RHS 0260
     1 ,DFBS(10),TSKIB(10)                                              RHS 0270
      COMMCN /GEOMSS/DETADX(11),DETADT(11),ARM1S(10),DFSS(10),TSKIS(10) RHS 0280
     1 ,ARM2S(10)                                                       RHS 0290
      COMMON /KSWTCH/ ITHRST                                            RHS 0300
      CCMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  RHS 0310
     -                AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO       RHS 0320
      COMMCN /MATRIX/ A(6,6)                                            RHS 0330
      COMMCN /MSIDW/ DF(2,10),DSWAV(2,10),FXH(2),FYH(2),FZH(2),FMH(2),  RHS 0340
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1                  FNH(2),VFY(2),VFZ(2),FXV                               RHS 0350
 COMMON /MWAVE/ FXW(2),FYW(2),FZW(2),FKW(2),FMW(2),FNW(2)                 RHS 0360
 COMMON /OPTION/ I3DOF,ISRGE,ITRIM,IDIA                                   RHS 0370
 COMMON /PLENUM/XLBW,XBBW,ABW,BUBHGT                                      RHS 0380
 COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT                            RHS 0390
 COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,         RHS 0400
-IRUD,IPROP,IAEROD,IRHS                                                   RHS 0410
 COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7         RHS 0420
 COMMON /PWAVE/ FNCON,PWVCON                                              RHS 0430
 COMMON/RUDDR/ NPR,DELRUD(25),XR,YR,ZR,IRDS,TL,RSPAN,RAREA,RASPR,         RHS 0440
ARCLB,RTC,RUDANG,TIR(25)                                                  RHS 0450
 COMMON /SIDE/FXSW,FYSW,FZSW,FKSW,FMSW,FNSW,ALSW,YSW,XLSW,CFSW,CDSWRHS 0460
1,VAREA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY,VZ  ,AVBMSW,DELX,VTC             RHS 0470
 COMMON/SLOPE/WATSLP,XPWV,XLXPWV,PWVHT,XPWVXS                             RHS 0480
 COMMON/SOFTBS/XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAVG RHS 0490
1B(10),CENCAB                                                             RHS 0500
 COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS                  RHS 0510
1 ,ELMAXS,YAVGS(10)                                                       RHS 0520
 COMMON / VALOLD / YOLD(20)                                               RHS 0530
 COMMON /VARBLE/ VAL(40)                                                  RHS 0540
 COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,               RHS 0550
1                FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                      RHS 0560
2               ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR                RHS 0570
 EQUIVALENCE (VAL(1),TIME),(VAL(2),U),(VAL(3),V),(VAL(4),W),              RHS 0580
1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),            RHS 0590
2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),RHS 0600
3(VAL(24),PB)                                                             RHS 0610
 EQUIVALENCE (VAL(18),FANPWR)                                             RHS 0620
 DATA NOTIN /0/                                                           RHS 0630
 DIMENSION ACCEL(3),ANGACL(3)                                             RHS 0640
 DIMENSION GF(6),VALUE(20)                                                RHS 0650
C                                                                         RHS 0660
  DO 5 J=1,20                                                             RHS 0670
5 VALUE(J)=0.0                                                            RHS 0680
C                                                                         RHS 0690
C    CALCULATION OF BUBBLE WAVE MAKING DRAG                               RHS 0700
C                                                                         RHS 0710
  AB=ABW-(ABW-(XL*WIDTH))*(ZS+Z)/BUBHGT                                   RHS 0720
  IF (IDIA.EQ.1) GO TO 6                                                  RHS 0730
  FN=U/FNCON                                                              RHS 0740
  CF=.37/(FN**1.5655981)                                                  RHS 0750
  FXPWAV=-PWVCON*PBBAR*CF                                                 RHS 0760
  WATSLP=-FXPWAV/WEIGHT                                                   RHS 0770
  VCL=VOLNOM-.5*(AB+ABW)*(Z+ZS)-DVOLW                                     RHS 0780
 1+.5*WATSLP*XL*AB                                                        RHS 0790
  GO TO 7                                                                 RHS 0800
C                                                                         RHS 0810
C   MEMERANE STUDY                                                        RHS 0820
```

```
C
 6    PBAR=VAL(24)-PINF
      VOL=VOLNOM-.5*(AB+ABW)*(Z+ZS)-DVOLW+PBAR*.3175333
 7    CONTINUE
      PB=PINF*(BMASS/(VOL*RHOINF))**GAM
      PBS=PB+DPBS
      PSS=PB+DPSS
      PBAR=PB-PINF
      ABPB=PBAR*AB

C     CALCULATION OF BUBBLE WAVE MAKING DRAG
C
      FLOW=SQRT(2.*ABS(PBAR)/RHOINF)*SIGN(1.,PBAR)
      QLSW=CFSW*ALSW*FLOW
C
      CALL BOWSL
      CALL STNSL
C
      GF(1)=FXBS+FXSS+FXSW+FXRUD+FXP+FXWAV+FXAED              +FXPWAV
      IF (ITHRST.NE.ITRIM) GO TO 11
      THSTS(1)=THSTS(1)-GF(1)/2.
      THSTP(1)=THSTP(1)-GF(1)/2.
      THST=THSTS(1)+THSTP(1)
      GF(1) = 0.0
   11 CONTINUE
      GF(2)=-R*U*AM+FYBS+FYSS+FYSW+FYRUD+FYP+FYWAV+FYAED
      GF(3)=WEIGHT-ABPB         +FZBS+FZSS+FZSW+FZRUD+FZP+FZWAV+FZAED
      GF(4)=FKBS+FKSS+FKSW+FKRUD+FKP+FKWAV+FKAED +ABPB*PHI*(-Z)
C
C     CALCULATION OF EFFECTIVE CENTER OF PRESSURE
C
      XCPU=XCP+0.001975*(U*0.5921-30.0)**2-0.974
      XCPC=SHXYAX(XCPU,ZCP,THETA,PI)
      FMBUB=ABPB*XCPC
      GF(5)=FMBS+FMSS+FMSW+FMRUD+FMP+FMWAV+FMAED+FMBUB+FXPWAV*ZS
      FWAVZ=FXPWAV*ZS
      GF(6)=FNBS+FNSS+FNSW+FNRUD+FNP+FNWAV+FNAED
      IF( I3DOF .NE. 1) GO TO 100
      GF(3)=0.0
      GF(5)=0.0
  100 CONTINUE
      DO 1 I=1,6
      VALUE(I)=0.0
      DO 1 J=1,6
      VALUE(I)=VALUE(I)+A(I,J)*GF(J)
    1 CONTINUE
      VALUE(7)=P
      VALUE(8)=Q
```

```
      VALUE(9)=W
      IF (I3DOF .EQ. 1 ) GO TO 325
C
C     BUBBLE PRESSURE EQUATION
C
      QOUT=QLBS+QLSS+QLSW
C
      CALL FAN
C
      QCNTRL=0.0
      VALUE(10)=RHOINF*(QIN-QOUT-QCNTRL)
      GO TO 236
 325  CONTINUE
      VALUE(10)=0.0
 236  CONTINUE
C
C     WRITE DATA FILE FOR MOMENT AND SHEAR CALCS., IF REQUIRED
C
      IF ( IMT.NE.1 )  GO TO 111
      NBS = NSTA(3)-1
      NSS = NSTA(4)-1
      NSSL = NSS/2+1
                         WRITE (IBMFIL)  (VAL(I),I=1,24),ZBAR,PHIBAR,THEBAR,
     -                   FXW,FYW,FZW,FKW,FMW,FNW,  (VALUE(I),I=1,10),
     -                   DF,DSWAV,FXH,FYH,FZH,FMH,FNH,VFY,VFZ,FXV ,
     -                   FXRUD,FYRUD,FXP,FYP,FZP,   FZSS,FKSS,FMSS,FXBS,FZBS,
     -                   FXAED,FYAED,FZAED,FMAED,FNAED,FXPWAV,FXSS,FKBS,FMBS
     X ,FNBS,FNSS ,(TSKIS(I),DFSS(I),I=NSSL,NSS)
     Y              ,(TSKIB(I),DFBS(I),ARM1B(I),ARM2B(I),I=1,NBS)
 111  CONTINUE
C
C     CONSTANT LONGITUDINAL VELOCITY ( U )
C
      IF (ISRGE .EQ.1) VALUE(1)=0.0
      IF (ON.NE.1) RETURN
      DO 2 I=1,3
      ACCEL(I)=VALUE(I)/G
      ANGACL(I)=VALUE(I+3)*RAD
   2  CONTINUE
      BOWACC=ACCEL(3)-XBOW*VALUE(5)/G
      STNACC=ACCEL(3)+XS*VALUE(5)/G
      IF(IVERT.NE.ON) GO TO 10
      ZD=Z+ZS
      VOLP=VOL
      THETAR=THETA*RAD
      QDEG=Q*RAD
  10  IF(ILATRL.NE.ON) GO TO 15
      DEPSI=PSI*RAD
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      PDEG=P*RAD                                                          RHS 1790
      RDEG=R*RAD                                                          RHS 1800
      BETAS=-V/U*RAD                                                      RHS 1810
      ACCLAT=(VALUE(2)+U*R)/G                                             RHS 1820
      DPHI=PHI*RAD                                                        RHS 1830
      DRFT=12.0*ZD                                                        RHS 1840
      VEL=0.5925*U                                                        RHS 1850
      DELRS=RUDANG*RAD                                                    RHS 1860
      IF(R.EQ.0.0) GO TO 115                                              RHS 1870
      TRADUS=U/R                                                          RHS 1880
      GO TO 20                                                            RHS 1890
  115 TRADUS=1.E8                                                         RHS 1900
   20 WRITE(1)TIME,VAL(16),DRFT,THETAR,PBAR,BOWACC,ACCEL(3),FANPWR,DPHI,RHS 1910
     1DEPSI,ACCLAT,VEL,TRADUS,VOLP,X,Y,QIN,QOUT,GF(1),FXPWAV,THSTS(1),THRHS 1920
     2STP(1),QDEG,PDEG,RDEG,DELRS                                         RHS 1930
   15 IF (IRHS .NE. ON) RETURN                                            RHS 1940
       WRITE(6,77) FMBS,FMSS,FMSW,FMRUD,FMP,FMWAV,FMAED,FMBUB,FWAVZ       RHS 1950
      WRITE(6,401)FXPWAV                                                  RHS 1960
      WRITE(6,200) PBAR,FANPWR,QIN,QLBS,QLSW,QLSS                         RHS 1970
      WRITE(6,215) AB,VOL                                                 RHS 1980
                    WRITE(6,213) VALUE,VAL                                RHS 1990
      WRITE(6,150) GF,ACCEL,ANGACL                                        RHS 2000
      WRITE(6,175)BOWACC,STNACC                                           RHS 2010
C                                                                         RHS 2020
   77 FORMAT('0',6X,5HFMBS=,E16.6,2X,5HFMSS=,E16.6,2X,5HFMSW=,            RHS 2030
     AE16.6,/,'0',6X,6HFMRUD=,E16.6,2X,4HFMP=,E16.6,2X,6HFMWAV=,E16.6,    RHS 2040
     B/,'0',6X,6HFMAED=,E16.6,2X,6HFMBUB=,E16.6,2X,6HFWAVZ=,E16.6)        RHS 2050
  401 FORMAT('0',6X,7HFXPWAV=,E16.6)                                      RHS 2060
  200 FORMAT(//10X,3HRHS                                                  RHS 2070
     120H GAGE PRESS. (PSF) = F7.2,5X,21HFAN POWER REQD (HP) =  F8.2,     RHS 2080
     25X,27HFAN FLOW RATE (CU FT/SEC) =  F9.2,                            RHS 2090
     3//31H LEAKAGE FLOW RATES (CU FT/SEC)  //11H BOW SEAL = F9.2,        RHS 2100
     411H SIDEWALL = F9.2,13H STERN SEAL = F9.2)                          RHS 2110
  215 FORMAT(/13H PLENUM AREA= F9.2,10X,14HPLENUM VOLUME= F10.2)          RHS 2120
  213 FORMAT(//12H VALUE ARRAY 2(/10E13.4)/10H VAL ARRAY 4(/10E13.4))     RHS 2130
  150 FORMAT(/10X,24HTOTAL FORCES AND MOMENTS 6E12.4/10X,24HACCELERATIONRHS 2140
     -S G,DEG/SEC2 6E12.4)                                                RHS 2150
  175 FORMAT(/10X,16HBOW ACCEL. (G) = E12.4,21H   STERN ACCEL. (G) = E12RHS 2160
     -.4)                                                                 RHS 2170
C                                                                         RHS 2180
      RETURN                                                              RHS 2190
      END                                                                 RHS 2200


C                                                                         BWSL0010
      SUBROUTINE BOWSL                                                    BWSL0020
C                                                                         BWSL0030
      INTEGER ON                                                          BWSL0040
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      COMMON /AIR/ PINF,RHOINF,GAM                                      BWSL0050
      COMMON /CONST/ PI,RAD,UO                                          BWSL0060
      COMMON /FORBS/ FX,FY,FZ,FK,FM,FN,QL                               BWSL0070
      COMMON /GEOM/ WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM,DELS(4,BWSL0080
     110),XCP,ZCP                                                       BWSL0090
      COMMON /GEOMBS/ DFTABX(11),DETABT(11),ARM1B(10),ARM2B(10),DFBS(10)BWSL0100
     1,TSKIB(10)                                                        BWSL0110
      COMMON /LEAKER/ ALEAK,BLEAK,CFSS,CFBS                             BWSL0120
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,AMBWSL0130
     1I(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO                         BWSL0140
      COMMON /PRTINT/ ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,IBWSL0150
     1RUD,IPROP,IAEROD,IRHS                                             BWSL0160
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7  BWSL0170
      COMMON /SLOPE/ WATSLP,XPWV,XLXPWV,PWVHT,XPWVXS                    BWSL0180
      COMMON /SOFTBS/ XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAVBWSL0190
     1GB(10),CENCAB                                                     BWSL0200
      COMMON /VARBLE/ VAL(40)                                           BWSL0210
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,FXWAV,FYBWSL0220
     1WAV,FZWAV,FKWAV,FMWAV,FNWAV,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBWSL0230
     2BAR                                                               BWSL0240
      DIMENSION ELSKID(11), WETLEN(11), BWSL(6,24), GAP(11), ELSKI(11), BWSL0250
     1DPFT(11), WTAB(6), ZTAB(6)                                        BWSL0260
      DATA NPTS,IBS/6,0/                                                BWSL0270
      DATA WTAB/0.0,3.75,5.42,6.67,7.5,8.42/                            BWSL0280
      DATA ZTAB/3.75,4.00,4.42,4.83,5.25,5.67/                          BWSL0290
      DATA ENU,UWSKI,CLSKI,HINGHT/1.28E-05,0.0,1.5708,1.875/            BWSL0300
      DATA BWSL/0.0,3.8,6.9,9.9,12.3,15.0,0.0,4.1,7.3,10.5,13.2,15.7,0.0BWSL0310
     1,4.3,7.7,11.0,13.7,16.7,0.0,4.7,8.2,11.5,14.5,17.4,0.0,5.2,8.9,12.BWSL0320
     24,15.4,18.3,0.0,5.5,9.6,13.3,16.1,19.6,0.0,5.8,9.9,13.8,17.1,20.6,BWSL0330
     30.0,6.1,10.6,14.7,18.4,21.9,0.0,6.4,11.0,15.3,19.3,23.3,0.0,6.6,11BWSL0340
     4.7,16.4,20.5,24.5,0.0,6.9,12.3,17.6,22.1,25.7,0.0,7.2,13.5,19.6,24BWSL0350
     5.1,28.3,0.0,8.2,15.3,21.7,26.3,31.3,0.0,9.6,17.5,24.2,29.7,34.6,0.BWSL0360
     60,11.9,20.0,26.7,32.3,38.0,0.0,14.0,22.5,30.0,35.8,41.0,0.0,17.5,2BWSL0370
     75.5,32.5,39.7,44.5,0.0,21.0,30.0,37.4,42.0,47.0,0.0,24.6,33.7,41.0BWSL0380
     8,45.0,48.7,0.0,29.4,38.5,45.0,48.7,48.7,0.0,33.0,45.0,48.7,48.7,48BWSL0390
     9.7,0.0,40.0,48.7,48.7,48.7,48.7,0.0,48.7,48.7.48.7,48.7,48.7,0.0,4BWSL0400
     $8.7,48.7,48.7,48.7,48.7/                                          BWSL0410
      DATA CORLEN/3.75/                                                 BWSL0420
      EQUIVALENCE (VAL(1),TIME), (VAL(2),U), (VAL(3),V), (VAL(4),W), (VABWSL0430
     1L(5),P), (VAL(6),Q), (VAL(7),R), (VAL(8),PHI), (VAL(9),THETA), (VABWSL0440
     2L(10),Z), (VAL(11),BMASS), (VAL(21),X), (VAL(22),Y), (VAL(23),PSI)BWSL0450
     3, (VAL(24),PB)                                                    BWSL0460
C                                                                       BWSL0470
      DO 1 J=1,11                                                       BWSL0480
      GAP(J) = 0.0                                                      BWSL0490
      ELSKI(J) = 0.0                                                    BWSL0500
      WETLEN(J) = 0.0                                                   BWSL0510
      ELSKID(J) = 0.0                                                   BWSL0520
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```
1 CONTINUE                                                              BWSL0530
  ALBS = 0.0                                                            BWSL0540
  FX = 0.0                                                              BWSL0550
  FZ = 0.0                                                              BWSL0560
  FK = 0.0                                                              BWSL0570
  FM = 0.0                                                              BWSL0580
  FN = 0.0                                                              BWSL0590
  DELPBG = PBS-PB                                                       BWSL0600
  IF (DELPBG.LT.0.0) DELPBG=0.0                                         BWSL0610
  PBAR = PB-PINF                                                        BWSL0620
  DELP = PBAR                                                           BWSL0630
  IF (DELP.LT.0.0) DELP=0.0                                             BWSL0640
  ARGO = ELMAXB/CORLEN                                                  BWSL0650
  ANGO = ARSIN(ARGO)                                                    BWSL0660
  X1 = XBS+ZBS*THETA-CORLEN*COS(ANGO)                                   BWSL0670
  Z1 = -Z-ZBS+XBS*THETA-ELMAXB*COS(THETA)                               BWSL0680
  DPTHFT = (5.5/(1.+(U/25.))**2.0)/12.0                                 BWSL0690
  IF (CENCAB.GT.1.1875) CENCAB=1.1875                                   BWSL0700
  N = NSTA(3)                                                           BWSL0710
  DO 3 K=1,N                                                            BWSL0720
  DPFT(K) = DPTHFT                                                      BWSL0730
  ELSKI(K) = (ETA(3,K)-DETABX(K)*(XX(3,K)-X1)-Z1)+YY(3,K)*PHI+XLXPWVBWSL0740
 1*WATSLP                                                               BWSL0750
  IF (ELSKI(K).GT.HINGHT) ELSKI(K)=HINGHT                               BWSL0760
  IF ((HINGHT-ELSKI(K)+DPFT(K)).GE.ELMAXB) DPFT(K)=ELMAXB-HINGHT+ELSBWSL0770
 1KI(K)                                                                 BWSL0780
  IF (DPFT(K).LT.0.0) DPFT(K)=0.0                                       BWSL0790
  ELSKID(K) = (ELSKI(K)-DPFT(K))*12.0                                   BWSL0800
  IF ((HINGHT-ELSKID(K)/12.0).GE.ELMAXB) ELSKID(K)=(HINGHT-ELMAXB)*1BWSL0810
 12.0                                                                   BWSL0820
  DPIN = DPFT(K)*12.0                                                   BWSL0830
  MM = DPIN                                                             BWSL0840
  MM1 = MM+1                                                            BWSL0850
  MM2 = MM1+1                                                           BWSL0860
  DINC = DPIN-MM                                                        BWSL0870
  GAP(K) = -ELSKI(K)+(HINGHT-ELMAXB)                                    BWSL0880
  IF (GAP(K).LT.0.0) GAP(K)=0.0                                         BWSL0890
  IF (ELSKID(K).GE.0.) GO TO 2                                          BWSL0900
  WETLEN(K) = ELSKI(K)                                                  BWSL0910
  GO TO 3                                                               BWSL0920
2 MM3 = ELSKID(K)                                                       BWSL0930
  MM4 = MM3+1                                                           BWSL0940
  MM5 = MM4+1                                                           BWSL0950
  DLINC = ELSKID(K)-MM3                                                 BWSL0960
  BWSL1 = BWSL(MM1,MM4)                                                 BWSL0970
  BWSL2 = BWSL(MM1,MM5)                                                 BWSL0980
  BWSL3 = BWSL(MM2,MM4)                                                 BWSL0990
  BWSL4 = BWSL(MM2,MM5)                                                 BWSL1000
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      BWSLA1 = (BWSL2-BWSL1)*DLINC+BWSL1                                BWSL1010
      BWSLA2 = (BWSL4-BWSL3)*DLINC+BWSL3                                BWSL1020
      WETLEN(K) = ((BWSLA2-BWSLA1)*DINC+BWSLA1)/12.0                    BWSL1030
    3 CONTINUE                                                          BWSL1040
      N = NSTA(3)-1                                                     BWSL1050
      DO 10 J=1,N                                                       BWSL1060
      WETLAV = (WETLEN(J+1)+WETLEN(J))/2.0                              BWSL1070
      IF (WETLAV.LE.0.001) GO TO 8                                      BWSL1080
      DPFTAV = (DPFT(J+1)+DPFT(J))/2.0                                  BWSL1090
      ELSKIA = (ELSKI(J+1)+ELSKI(J))/2.0                                BWSL1100
      ELSKDA = (ELSKID(J+1)+ELSKID(J))/24.0                             BWSL1110
      SEALHT = HINGHT-ELSKDA                                            BWSL1120
      DIFF = 2.0*CENCAB-(SEALHT+0.5)                                    BWSL1130
      IF (DIFF.GT.0.5) DIFF=0.5                                         BWSL1140
      ARM1B(J) = X1+WETLAV/2.0                                          BWSL1150
      ARM2B(J) = ZS-ELSKIA+DPFTAV/2.0                                   BWSL1160
      IF (DIFF.GE.0.25) GO TO 4                                         BWSL1170
      DFBS(J) = -DELP*DELYBS*WETLAV                                     BWSL1180
      GO TO 7                                                           BWSL1190
    4 FORLEN = XBF-WETLAV                                               BWSL1200
      IF (FORLEN.EQ.0.0) GO TO 5                                        BWSL1210
      ARGW = (HINGHT-ELSKIA)/FORLEN                                     BWSL1220
      IF (ARGW.GT.1.0) ARGW=1.0                                         BWSL1230
      ANGW = ARSIN(ARGW)                                                BWSL1240
      FORCOS = COS(ANGW)                                                BWSL1250
      GO TO 6                                                           BWSL1260
    5 FORCOS = 0.0                                                      BWSL1270
    6 DFBS(J) = -DELP*DELYBS*WETLAV-DELP*FORLEN*DELYBS*FORCOS*((FORLEN*0BWSL1280
     1.5*FORCOS)/(FORLEN*FORCOS+WETLAV/2.0))*((DIFF-0.25)*4.0)          BWSL1290
    7 ARG = 0.5*RHO*U*U*WETLAV*DELYBS                                   BWSL1300
      RESKI = U*WETLAV/ENU                                              BWSL1310
      CDTSKI = 0.427/(ALOG10(RESKI)-0.407)**2.64                        BWSL1320
      TSKIB(J) = -ARG*CDTSKI                                            BWSL1330
      GO TO 9                                                           BWSL1340
    8 DFBS(J) = 0.0                                                     BWSL1350
      TSKIB(J) = 0.0                                                    BWSL1360
    9 CONTINUE                                                          BWSL1370
      FX = FX+TSKIB(J)                                                  BWSL1380
      FZ = FZ+DFBS(J)                                                   BWSL1390
      FK = FK+DFBS(J)*YAVGB(J)                                          BWSL1400
      FM = FM-DFBS(J)*ARM1B(J)+TSKIB(J)*ARM2B(J)                        BWSL1410
      FN = FN-TSKIB(J)*YAVGB(J)                                         BWSL1420
      ALBS = ALBS+(GAP(J)+GAP(J+1))*DELYBS/2.0                          BWSL1430
   10 CONTINUE                                                          BWSL1440
      ALBS = ALBS+BLEAK                                                 BWSL1450
      SQFAC = SQRT(2.*ABS(PBAR)/RHOINF)                                 BWSL1460
      QL = CFBS*ALBS*SQFAC*SIGN(1.,PBAR)                                BWSL1470
      IF (IBOWSL.NE.ON) RETURN                                          BWSL1480
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      WRITE (6,11) GAP,WETLEN,FX,FY,FZ,FK,FM,FN                         BWSL1490
C                                                                       BWSL1500
   11 FCRMAT (//10X,8HBOW SEAL/26H GAP (FT.) (PORT TO STBD.)/11F10.5/28HBWSL1510
     1 WETLEN(FT.) (PORT TO STBD.)/11F10.5/10X,23HBOWSL FX,FY,FZ,FK,FM,FBWSL1520
     2N/6E15.4)                                                         BWSL1530
C                                                                       BWSL1540
      RETURN                                                            BWSL1550
      END                                                               BWSL1560
C                                                                       SDWL0010
      SUBROUTINE SIDEWL                                                 SDWL0020
C                                                                       SDWL0030
      INTEGER ON                                                        SDWL0040
      COMMON /AIR/ PINF,RHOINF,GAM                                      SDWL0050
      COMMON /BMCO / IMM,IMNX,IMNY,IBMFIL,BTIME,IMT,XMI(10),YMI(7),IX,IYSDWL0060
      CCMMON /CONST/ PI,RAD,U0                                          SDWL0070
      CCMMCN /GEOM/    WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM     SDWL0080
     1,DELS(4,10),XCP,ZCP                                               SDWL0090
      COMMON /GEOMSW/ XAVG(10),DS                                       SDWL0100
      COMMON /KSWTCH/ ITHRST                                            SDWL0110
      COMMCN /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,  SDWL0120
     -                AMI(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO       SDWL0130
      CCMMON /MSIDW/ DF(2,10),DSWAV(2,10),FXH(2),FYH(2),FZH(2),FMH(2),  SDWL0140
     1               FNH(2),VFY(2),VFZ(2),FXV                           SDWL0150
      COMMCN /PLENUM/XLBW,XBBW,ABW,BUBHGT                               SDWL0160
      COMMON /PRIME/ STIME,FTIME,DELT,DELPNT,TPRINT                     SDWL0170
      COMMON /PRTINT/ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,  SDWL0180
     -IRUD,IPROP,IAEROD,IRHS                                            SDWL0190
      CCMMCN /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7  SDWL0200
      COMMON /SIDE/FX   ,FY   ,FZ   ,FK   ,FM   ,FN   ,ALSW,YSW,XLSW,CFSW,CDSWSDWL0210
     1,VAREA  ,VCHORD,VSPAN,VANGLE,VCOS,VX,VY,VZ  ,AVBMSW,DELX,VTC      SDWL0220
      CCMMCN /SLOPE/WATSLP,XPWV,XLXPWV,XPWVXS                           SDWL0230
      CCMMON /VARBLE/ VAL(40)                                           SDWL0240
      CCMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVCLW,NWAVE,BETA,        SDWL0250
     1              FXWAV,FYWAV,FZWAV,FKWAV,FMWAV,FNWAV                 SDWL0260
     2              ,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PBBAR          SDWL0270
      COMMON /WAVTAB/ NAL,DAL,SAL,NDS,DDS,SDS,NTH,DTH,STH,NBB,DBB,SBB,  SDWL0280
     1          AC1(20,5,7),AC2(20,5,7),AC3(20,5,7),AC4(20,5,7),        SDWL0290
     2          AC5(20,5,7),AC6(20,5,7),AC7(20,5,7)                     SDWL0300
     3          ,AC0(20,5,7),AC00(20,5,7),AC8(20,5,7),                  SDWL0310
     4          AS1(20,5,7),AS2(20,5,7),AS3(20,5,7),AS4(20,5,7),        SDWL0320
     5          AS5(20,5,7),AS6(20,5,7),AS7(20,5,7)                     SDWL0330
     6          ,AS0(20,5,7),AS00(20,5,7),AS8(20,5,7)                   SDWL0340
     7          ,BB(36),XREF,RX                                         SDWL0350
      EQUIVALENCE            (VAL(2),U),(VAL(3),V),(VAL(4),W),          SDWL0360
     1(VAL(5),P),(VAL(6),Q),(VAL(7),R),(VAL(8),PHI),(VAL(9),THETA),     SDWL0370
     2(VAL(10),Z),(VAL(11),BMASS),(VAL(21),X),(VAL(22),Y),(VAL(23),PSI),SDWL0380
     3(VAL(24),PB)                                                      SDWL0390
```

```
      DIMENSION GAP(2,11),DSW(2,11)                                     SDWL0400
      DIMENSION FZHOLD(2), FZHDRP(2)                                    SDWL0410
      DATA ENU /1.28E-5/                                                SDWL0420
C                                                                       SDWL0430
      PBHEAD= PBAR/(RHO*G)                                              SDWL0440
C                                                                       SDWL0450
C     GAP OR WETTED DRAFT CALCULATION                                   SDWL0460
C                                                                       SDWL0470
      DO 10 J=1,2                                                       SDWL0480
      N=NSTA(J)                                                         SDWL0490
      DO 10 K=1,N                                                       SDWL0500
      DD=ZS+Z+YY(J,K)*PHI-XX(1,K)*THETA+ETA(J,K)                        SDWL0510
      DDIN=DD-WATSLP*(XPWVXS-XX(J,K))                                   SDWL0520
      IF(DDIN.LT.BUBHGT) GO TO 101                                      SDWL0530
      IF ( VAL(1)-TOLD .LT. DELPNT )  GO TO 101                         SDWL0540
      TOLD = VAL(1)                                                     SDWL0550
      WRITE (6,100) XX(J,K),VAL(1),DD                                   SDWL0560
  100 FORMAT(/10X,43HWATER CONTACT WITH TOP OF BUBBLE CHAMBER AT F7.2,  SDWL0570
     -14H FT.    TIME = F7.2,19H SEC.    IMMERSION= F7.2,4H FT. )       SDWL0580
  101 CONTINUE                                                          SDWL0590
      DSW(J,K)=(SIGN(1.,DD)+1.)*DD/2.                                   SDWL0600
      IF (DDIN) 6,8,8                                                   SDWL0610
    6 IF(DSW(J,K)-PBHEAD) 7,8,8                                         SDWL0620
    7 GAP(J,K)=-DDIN*(1.-(DSW(J,K))/PBHEAD)                             SDWL0630
      GO TO 10                                                          SDWL0640
    8 GAP(J,K)=0.0                                                      SDWL0650
   10 CONTINUE                                                          SDWL0660
C                                                                       SDWL0670
C     LEAKAGE AREA                                                      SDWL0680
C                                                                       SDWL0690
      ALSW=0.0                                                          SDWL0700
      DO 20 J=1,2                                                       SDWL0710
      N=NSTA(J)-1                                                       SDWL0720
      DO 20 I=1,N                                                       SDWL0730
      ALSW=ALSW+(GAP(J,I)+GAP(J,I+1))*DELX/2.                           SDWL0740
   20 CONTINUE                                                          SDWL0750
C                                                                       SDWL0760
C     CROSS-FLOW DRAG ON SIDEWALLS                                      SDWL0770
C                                                                       SDWL0780
      FYD=0.0                                                           SDWL0790
      FKD=0.0                                                           SDWL0800
      FND=0.0                                                           SDWL0810
      DO 15 I=1,2                                                       SDWL0820
      N=NSTA(I)-1                                                       SDWL0830
      DO 15 J=1,N                                                       SDWL0840
      DSWAV(I,J)=(DSW(I,J)+DSW(I,J+1))/2.                               SDWL0850
      VREL     =V+XAVG(J)*R-(ZS-DSWAV(I,J)/2.)*P                        SDWL0860
      DF(I,J)=-  HRHO*CDSW*VREL     *ABS(VREL     )*DELX    *DSWAV(I,J)SDWL0870
```

```
      FYD=FYD+DF(I,J)                                                   SDWL0880
      FND=FND+DF(I,J)*XAVG(J)                                           SDWL0890
   15 FKD=FKD-(ZS-DSWAV(I,J)/2.)*DF(I,J)                                SDWL0900
C                                                                       SDWL0910
C     SET UP STERN LIMIT OF FORCE DETERMINATION                         SDWL0920
C                                                                       SDWL0930
      XSS = -XS                                                         SDWL0940
      GO TO 16                                                          SDWL0950
      ENTRY SIDWLM                                                      SDWL0960
      XSS = XMI(IX)                                                     SDWL0970
   16 IP=1.+(THETA*RAD-STH)/DTH                                         SDWL0980
      IP=MAX0(MIN0(IP,NTH),1)                                           SDWL0990
      IP1=MIN0(IP+1,NTH)                                                SDWL1000
      DTHETA=(IP-1)*DTH+STH                                             SDWL1010
      DIP= (THETA*RAD-DTHETA)/DTH                                       SDWL1020
C                                                                       SDWL1030
C     CALC REYNOLDS NO. AND DRAG COEFF.                                 SDWL1040
C                                                                       SDWL1050
      REY=U*XLSW/ENU                                                    SDWL1060
      CDT=.427/(ALOG10(REY)-.407)**2.64                                 SDWL1070
C                                                                       SDWL1080
C     SIDEWALL FORCES, P/S                                              SDWL1090
C                                                                       SDWL1100
      DO 40 J=1,2                                                       SDWL1110
      WAREA=0.0                                                         SDWL1120
      N=NSTA(J)-1                                                       SDWL1130
      NI = (XSS+XS)*N/XLSW+1.5                                          SDWL1140
      DO 21 I=NI,N                                                      SDWL1150
      ZOR1=1.                                                           SDWL1160
      IF(DSWAV(J,I).EQ. 0.0) ZOR1=0.0                                   SDWL1170
   21 WAREA=WAREA+DELX*(2.*DSWAV(J,I)+ZOR1*AVBMSW)                      SDWL1180
      FXH(J)=-  HRHO*CDT*WAREA*U*U                                      SDWL1190
      PM1=2*J-3                                                         SDWL1200
      YLSW=PM1*YSW                                                      SDWL1210
      DS= Z    +ZS+YLSW*PHI                                             SDWL1220
      DSS=DS-XSS*THETA                                                  SDWL1230
      ZOR1=(SIGN(1.,DSS)+1.)/2.                                         SDWL1240
      DSS=DSS*ZOR1                                                      SDWL1250
      IDSS=1.5+(DSS-SBB)/DBB                                            SDWL1260
      IDSS=MIN0(NBB,IDSS)                                               SDWL1270
      BS=BB(IDSS)                                                       SDWL1280
      ZOR1=(SIGN(1.,DSS)+1.)/2.                                         SDWL1290
      DSS=DSS*ZOR1                                                      SDWL1300
      DRBOW=DSS-(XX(J,N+1)-XSS)*THETA                                   SDWL1310
      IF(DRBOW.LT.0.0) DRBOW=0.0                                        SDWL1320
      A33S=(RHO*PI*BS**2)/8.                                            SDWL1330
      A22S=(RHO*.4*PI*DSS**2)/2.                                        SDWL1340
      IF(THETA.LT.0.0) A22S=.4*RHO*PI*DRBOW*DRBOW/2.                    SDWL1350
```

```
      DSR=DS-(XREF-XS)*THETA                                            SDWL1360
      ID=1.+(DSR*12.-SDS)/DDS                                           SDWL1370
      ID=MAX0(MIN0(ID,NDS),1)                                           SDWL1380
      DDSR =(ID-1)*DDS +SDS                                             SDWL1390
      ID1=MIN0(ID+1,NDS)                                                SDWL1400
      DID= (DSR*12.-DDSR)/DDS                                           SDWL1410
      BCO=ACO( 1,ID,IP)                                                 SDWL1420
      BCOO=ACOO( 1,ID,IP)                                               SDWL1430
      BC2=AC2( 1,ID,IP)                                                 SDWL1440
      BC5 = AC5(1,ID,IP)                                                SDWL1450
      BC6 = AC6(1,ID,IP)                                                SDWL1460
      BCO =BCO +DID*(ACO (1,ID1,IP)-BCO ) +DIP*(ACO (1,ID,IP1)-BCO      SDWL1470
     1    +DID*(ACO (1,ID1,IP1)-ACO (1,ID,IP1)-ACO (1,ID1,IP)+BCO ))    SDWL1480
      BCOO=BCOO+DID*(ACOO(1,ID1,IP)-BCOO) +DIP*(ACOO(1,ID,IP1)-BCOO     SDWL1490
     1    +DID*(ACOO(1,ID1,IP1)-ACOO(1,ID,IP1)-ACOO(1,ID1,IP)+BCOO))    SDWL1500
      BC2 =BC2 +DID*(AC2 (1,ID1,IP)-BC2 ) +DIP*(AC2 (1,ID,IP1)-BC2      SDWL1510
     1    +DID*(AC2 (1,ID1,IP1)-AC2 (1,ID,IP1)-AC2 (1,ID1,IP)+BC2 ))    SDWL1520
      BC5 =BC5 +DID*(AC5 (1,ID1,IP)-BC5 ) +DIP*(AC5 (1,ID,IP1)-BC5      SDWL1530
     1    +DID*(AC5 (1,ID1,IP1)-AC5 (1,ID,IP1)-AC5 (1,ID1,IP)+BC5 ))    SDWL1540
      BC6 =BC6 +DID*(AC6 (1,ID1,IP)-BC6 ) +DIP*(AC6 (1,ID,IP1)-BC6      SDWL1550
     1    +DID*(AC6 (1,ID1,IP1)-AC6 (1,ID,IP1)-AC6 (1,ID1,IP)+BC6 ))    SDWL1560
C                                                                       SDWL1570
C     SHIFT MOMENT CENTER FROM XREF TO C.G.                             SDWL1580
C                                                                       SDWL1590
      BCOO = BCOO-(XS-XREF)*BCO                                         SDWL1600
      BC6  = BC6 -(XS-XREF)*BC5                                         SDWL1610
C                                                                       SDWL1620
C     HYDROSTATIC AND HYDRODYNAMIC FORCES                               SDWL1630
C                                                                       SDWL1640
      FZH(J) =-G*BCO-U*U*A33S*THETA-U*A33S*W+Q*U*(-BC2+A33S*XSS)        SDWL1650
     1   -U*A33S*P*YLSW                                                 SDWL1660
      FMH(J) =-U*XSS*XSS*A33S*Q+G*BCOO+U*(A33S*XSS+BC2)*(W+U*THETA      SDWL1670
     1  +YLSW*P)                                                        SDWL1680
      FYH(J) =-A22S*U*(V+XSS*R  -ZS*P)                                  SDWL1690
      FNH(J) = FYH(J)*XSS-U*((V-ZS*P)*BC5+R*BC6)                        SDWL1700
C                                                                       SDWL1710
C     ADD VERTICAL FORCE DUE TO DEADRISE PROJECTION OF LATERAL FORCE    SDWL1720
C                                                                       SDWL1730
      CTNDR=0.0                                                         SDWL1740
      IF(DSS.LE.0.0) GO TO 22                                           SDWL1750
      CTNDR=(BS-BB(1))/DSS                                              SDWL1760
      IF(THETA.LT.0.0) CTNDR=.39391                                     SDWL1770
   22 CONTINUE                                                          SDWL1780
      FZHOLD(J)=FZH(J)                                                  SDWL1790
      FZHDRP(J)=PM1*FYH(J)*CTNDR*PROMO1                                 SDWL1800
      FZH(J)=FZH(J)+FZHDRP(J)                                           SDWL1810
      IF (IMT.EQ.2)  GO TO 40                                           SDWL1820
C                                                                       SDWL1830
```

```
C      CALC OF FORCE ON VENTRAL FINS REMOVED
C
39     CCNTINUE
40     CONTINUE
       IF (IMT.EQ.2) GO TO 41
C
C      TOTAL SIDEWALL FORCES AMD MOMENTS
C
       FX=FXH(1)+FXH(2)
       FY=FYH(1)+FYH(2)
       FZ=FZH(1)+FZH(2)
       FK=(FZH(2)-FZH(1))*YSW            +FKD  -FY*ZS
       FY=FY+FYD
       FM=FMH(1)+FMH(2)+ZS*FX
       FN= FND  +FNH(1)+FNH(2)  +(FXH(1)-FXH(2))*YSW
C
C      DRAG FORCE ON FINS REMOVED
C
    41 CCNTINUE
C
C      ADD ROLL DAMPING DUE TO VERTICAL WAVE GENERATION
C
       DSS=Z+ZS-XSS*THETA
       ZOR1=(SIGN(1.,DSS)+1.)/2.
       DSS=DSS*ZORI
       DS=Z+ZS
       DSR=DS-(XREF-XS)*THETA
       ID=1.+(DSR*12.-SDS)/DDS
       ID=MAXO(MINO(ID,NDS),1)
       DDSR=(ID-1)*DDS+SDS
       ID1=MINO(ID+1,NDS)
       DID= (DSR*12.-DDSR)/DDS
       BC2=AC2(1,ID,IP)
       BC2=BC2  +DID*(AC2 (1,ID1,IP)-BC2 ) +DIP*(AC2 (1,ID,IP1)-BC2
      1    +DID*(AC2 (1,ID1,IP1)-AC2 (1,ID,IP1)-AC2 (1,ID1,IP)+BC2 ))
       FKOLD=FK
       FK=FK-PROMO2*YSW*YSW*BC2*P/PI
       FZH(1)=FZH(1)+PROMO2/2.*YSW*BC2*P/PI
       FZH(2)=FZH(2)-PROMO2/2.*YSW*BC2*P/PI
       IF(PROMO3.EQ.1.0) WRITE(6,200) VAL(1), FZHOLD(1), FZHOLD(2),
      1FZHDRP(1), FZHDRP(2), FZH(1), FZH(2), FKOLD, FK
   200 FORMAT(/2X,'TIME=',1X,E15.4,2X,'OLD VERTICAL FORCES',2(5X,E15.4)/
      125X,'VERTICAL DEADRISE FORCES',2(5X,E15.4)/25X,'NEW VERTICAL FORCE
      2S',2(5X,E15.4)/25X,'OLD AND NEW ROLL MOMENTS',2(5X,E15.4)/)
       IF (ISIDWL.NE.ON) RETURN
       DC 42 I=1,2
       DO 42 J=1,11
       GAP(I,J)=12.0*GAP(I,J)
```

```
   42 DSW(I,J)=12.0*DSW(I,J)
      WRITE( 6,123) ((GAP(I,J),J=1,11),I=1,2),((DSW(I,J),J=1,11),I=1,2),
     1 FX,FY,FZ,FK,FM,FN
C
  123 FORMAT(/10X,8HSIDEWALL /25H GAP (FT.) (STERN TO BOW) /14H PORT SID
     1EWALL /11F10.5/14H STBD SIDEWALL /11F10.5/37H IMMERSION DEPTH (FT.
     2) (STERN TO BOW) /14H PORT SIDEWALL /11F10.5/14H STBD SIDEWALL /
     3 11F10.5/10X,26HSIDEWALL FX,FY,FZ,FK,FM,FN /6E15.4)
C
      RETURN
      END



C
      SUBROUTINE STNSL
C
      INTEGER ON
      COMMON /AIR/ PINF,RHOINF,GAM
      COMMON /CONST/ PI,RAD,UO
      COMMON /FORSS/ FX,FY,FZ,FK,FM,FN,QL,FMS
      COMMON /GEOM/ WIDTH,XL,XX(4,11),YY(4,11),NSTA(4),AB,VOLNOM,DELS(4,
     110),XCP,ZCP
      COMMON /GEOMSS/ DETADX(11),DETADT(11),ARM1S(10),DFSS(10),TSKIS(10)
     1,ARM2S(10)
      COMMON /KSWTCH/ ITHRST
      COMMON /LEAKER/ ALEAK,CFSS
      COMMON /MASSES/ AM,AIXX,AIYY,AIZZ,AIXZ,AIMAX,G,WEIGHT,RHO,NMASS,AM
     1I(201),XI(201),YI(201),ZI(201),XS,ZS,HRHO
      COMMON /PRTINT/ ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,I
     1RUD,IPROP,IAEROD,IRHS
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
      COMMON/SLOPE/WATSLP,XPWV,XLXPWV,PWVHT,XPWVXS
      COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS,ELMAXS,YAV
     1GS(10)
      COMMON /STSLR/ CPHI,CPHID
      COMMON /VALOLD/ YOLD(20)
      COMMON /VARBLE/ VAL(40)
      COMMON /WAVE/ ETA(4,11),AW(10),OMEGA(10),DVOLW,NWAVE,BETA,FXWAV,FY
     1WAV,FZWAV,FKWAV,FMWAV,FNWAV,ZBAR,PHIBAR,THEBAR,TC,COSBET,SINBET,PB
     2BAR
      EQUIVALENCE (VAL(1),TIME), (VAL(2),U), (VAL(3),V), (VAL(4),W), (VA
     1L(5),P), (VAL(6),Q), (VAL(7),R), (VAL(8),PHI), (VAL(9),THETA), (VA
     2L(10),Z), (VAL(11),BMASS), (VAL(21),X), (VAL(22),Y), (VAL(23),PSI)
     3, (VAL(24),PB)
      DIMENSION GAP(11), ELSKI(11), ELSKIL(11), AIRLEN(11), CTNSL(6,24)
      DATA ENU,UWSKI,CLSKI,GPS,HINGHT/1.28E-5,0.0,1.5708,.4644,1.875/
      DATA CTNSL/0.0,3.8,7.0,9.9,12.3,15.0,0.0,4.1,7.3,10.5,13.2,15.7,0.
```

```
      10,4.3,7.7,11.0,13.7,16.7,0.0,4.7,8.2,11.5,14.5,17.4,0.0,5.2,8.9,12SSL 0350
      2.4,15.4,18.3,0.0,5.5,9.4,13.1,16.1,19.2,0.0,5.8,9.9,13.8,17.1,20.6SSL 0360
      3,0.0,6.1,10.6,14.7,18.4,21.9,0.0,6.4,11.0,15.3,19.3,23.3,0.0,6.6,1SSL 0370
      41.7,16.4,20.5,24.5,0.0,6.9,12.3,17.6,22.1,25.7,0.0,7.2,13.5,19.6,2SSL 0380
      54.1,28.3,0.0,8.2,15.3,22.1,26.3,30.8,0.0,9.6,17.5,24.2,29.7,34.6,0SSL 0390
      6.0,11.9,20.0,25.4,32.3,38.0,0.0,14.0,23.3,30.0,35.8,41.0,0.0,17.5,SSL 0400
      725.5,32.5,39.7,44.5,0.0,21.6,30.0,38.7,42.0,47.0,0.0,24.6,33.7,41.SSL 0410
      80,45.0,48.7,0.0,28.3,38.5,45.0,48.7,48.7,0.0,35.0,45.0,48.7,48.7,4SSL 0420
      98.7,0.0,40.0,48.7,48.7,48.7,48.7,0.0,48.7,48.7,48.7,48.7,48.7,0.0,SSL 0430
      $48.7,48.7,48.7,48.7,48.7/                                          SSL 0440
C                                                                         SSL 0450
      IF (ELMAXS.GT.HINGHT) ELMAXS=HINGHT                                 SSL 0460
      DO 1 J=1,11                                                         SSL 0470
      GAP(J) = 0.0                                                        SSL 0480
      ELSKI(J) = 0.0                                                      SSL 0490
      ELSKIL(J) = 0.0                                                     SSL 0500
      AIRLEN(J) = 0.0                                                     SSL 0510
    1 CONTINUE                                                            SSL 0520
C                                                                         SSL 0530
C     'EFDEP' IS THE EFFECTIVE LIFTING DEPTH OF THE STERN SEAL            SSL 0540
C                                                                         SSL 0550
      EFDEP = 6.0                                                         SSL 0560
      MM = EFDEP                                                          SSL 0570
      ALSS = 0.0                                                          SSL 0580
      FX = 0.0                                                            SSL 0590
      FZ = 0.0                                                            SSL 0600
      FK = 0.0                                                            SSL 0610
      FM = 0.0                                                            SSL 0620
      FN = 0.0                                                            SSL 0630
      AGAP1 = 0.0                                                         SSL 0640
      AGAP2 = 0.0                                                         SSL 0650
      AGAPA1 = 0.0                                                        SSL 0660
      DELP = PSS-PB                                                       SSL 0670
      IF (DELP.LT.0.0) DELP=0.0                                           SSL 0680
      PBAR = PB-PINF                                                      SSL 0690
C                                                                         SSL 0700
C     CALCULATE ELSKI HERE.                                               SSL 0710
C                                                                         SSL 0720
      SINDIF = SINTH-COSTH*THETA                                          SSL 0730
      COSDIF = COSTH+SINTH*THETA                                          SSL 0740
      X1 = XSS+ZSS*THETA-XLF*SINDIF                                       SSL 0750
      Z1 = (-Z-ZSS+XSS*THETA-ELMAXS*COS(THETA))                           SSL 0760
C                                                                         SSL 0770
C     CALCULATE GAP HERE.                                                 SSL 0780
C                                                                         SSL 0790
      N = NSTA(4)                                                         SSL 0800
      DO 2 K=1,N                                                          SSL 0810
      ELSKI(K) = (ETA(4,K)-DETADX(K)*(XX(4,K)-X1)-Z1)+YY(4,K)*PHI         SSL 0820
```

```
     1-XPWV*WATSLP
      IF (ELSKI(K).GT.HINGHT) ELSKI(K)=HINGHT
      ELSKIL(K) = ELSKI(K)+GPS
      IF (ELSKIL(K).GT.HINGHT) ELSKIL(K)=HINGHT
      IF (ELSKIL(K).LT.(HINGHT-ELMAXS)) ELSKIL(K)=HINGHT-ELMAXS
      GAP(K) = -ELSKI(K)+(HINGHT-ELMAXS)
      IF (GAP(K).LT.0.0) GAP(K)=0.0
      MM1 = ELSKIL(K)*12.0
      MM2 = MM1+1
      MM3 = MM2+1
      DLINC = ELSKIL(K)*12.0-MM1
      STNSL1 = CTNSL(MM,MM2)
      STNSL2 = CTNSL(MM,MM3)
      AIRLEN(K) = ((STNSL2-STNSL1)*DLINC+STNSL1)/12.0
    2 CONTINUE
      N = NSTA(4)-1
      DO 5 J=1,N
      ELSKIA = (ELSKI(J+1)+ELSKI(J))/2.
      ELSKLA = (ELSKIL(J+1)+ELSKIL(J))/2.0
      AIRLAV = (AIRLEN(J+1)+AIRLEN(J))/2.0
      AGAP = ELSKLA-ELSKIA
      AGAP1 = AGAP
      IF (AGAP.LT.GPS) AGAP=GPS
      IF (AGAP1.GT.GPS) AGAP1=GPS
      ARM1S(J) = XX(4,J)+ELSKIA/2.
      ARM2S(J) = ZS-ELSKIA
      DFSS(J) = -DELP*DELYSS*AIRLAV/(GPS/AGAP)**2.0
      IF (AIRLAV.LE.0.0) GO TO 3
      ARG = .5*RHO*U*U*AIRLAV*DELYSS
      RESKI = U*AIRLAV/ENU
      CDTSKI = .427/(ALOG10(RESKI)-.407)**2.64
      TSKIS(J) = -ARG*CDTSKI
C
C     THE FOLLOWING CARD REMOVES WATER DRAG EFFECTS OF STERN SEAL
C
      TSKIS(J) = 0.0
      GO TO 4
    3 TSKIS(J) = 0.0
    4 CONTINUE
      FX = FX+TSKIS(J)
      FZ = FZ+DFSS(J)
      FK = FK+DFSS(J)*YAVGS(J)
      FM = FM-DFSS(J)*ARM1S(J)+TSKIS(J)*ARM2S(J)
      FN = FN-TSKIS(J)*YAVGS(J)
      ALSS = ALSS+(GAP(J)+GAP(J+1))*DELYSS/2.0
      AGAP2 = AGAP2+AGAP1
      AGAPA1 = AGAP2/J
    5 CONTINUE
```

```
      ALSS = ALSS+ALEAK*(AGAPA1/GPS)
      SQFAC = SQRT(2.*ABS(PBAR)/RHOINF)
      QL = CFSS*ALSS*SQFAC*SIGN(1.,PBAR)
      IF (ISTNSL.NE.ON) RETURN
      WRITE (6,6) GAP,AIRLEN,FX,FY,FZ,FK,FM,FN
C
    6 FORMAT (//12H  STERN SEAL/26H  GAP (FT.) PORT TO STBD. /11E11.3/28
     1H  AIRLEN(FT.) PORT TO STBD. /11E11.3/10X,23HSTNSL FX,FY,FZ,FK,FM,
     2FN/6E15.4)
C
      RETURN
      END


C
      SUBROUTINE FAN
C
      INTEGER ON
      COMMON /AIR/ PINF,RHOINF,GAM
      COMMON /FANMAP/ QIN,QBFAN(25),QMFAN(25),QSFAN(25),ENBFAN,ENMFAN,EN
     1SFAN,BRPM,EMRPM,SRPM,NPTSB,NPTSM,NPTSS,PBFAN(25),PMFAN(25),PSFAN(2
     25),TMEB(25),DELB(25),NB,TMES(25),DELS(25),NS
      COMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
      COMMON /PRTINT/ ON,IACCEL,IVEL,ITRAJ,ISIDWL,IBOWSL,ISTNSL,IWAVES,I
     1RUD,IPROP,IAEROD,IRHS
      COMMON /SOFTBS/ XBF,PBS,SINBS,COSBS,XBS,ZBS,DELYBS,DPBS,ELMAXB,YAV
     1GB(10)
      COMMON /SOFTSS/ XLF,PSS,SINTH,COSTH,XSS,ZSS,DELYSS,DPSS,ELMAXS,YAV
     1GS(10)
      COMMON /VARBLE/ VAL(40)
      DIMENSION QB(1), QM(1), QS(1), PBOW(1), PM(1), PS(1), HP(8)
      EQUIVALENCE (VAL(1),TIME), (VAL(2),U), (VAL(3),V), (VAL(4),W), (VA
     1L(5),P), (VAL(6),Q), (VAL(7),R), (VAL(8),PHI), (VAL(9),THETA), (VA
     2L(10),Z), (VAL(11),BMASS), (VAL(21),X), (VAL(22),Y), (VAL(23),PSI)
     3, (VAL(24),PB)
      EQUIVALENCE (VAL(18),FANPWR)
      EQUIVALENCE (QBFAN(1),QB(1)), (QMFAN(1),QM(1)), (QSFAN(1),QS(1)),
     1(PBFAN(1),PBOW(1)), (PMFAN(1),PM(1)), (PSFAN(1),PS(1))
      DATA HP/2.9,2.3,1.95,1.77,1.85,2.05,1.93,1.62/
C
      BRAT = 8000/BRPM
      EMRAT = 8000/EMRPM
      SRAT = 8000/SRPM
      TL = VAL(1)
      IF (NB.EQ.0.0) GO TO 1
      DPBS = FG1(TL,NB,TMEB,DELB,ILB)
      PBS = PB+DPBS
```

```
1 IF (NS.EQ.0.0) GO TO 2
  DPSS = FG1(TL,NS,TMES,DELS,ILS)
  PSS = PB+DPSS
2 CONTINUE
  PB1 = PBS-PINF
  PB2 = PB-PINF
  PB3 = PSS-PINF
  PBARB = PB1*BRAT**2
  PBARM = PB2*EMRAT**2
  PBARS = PB3*SRAT**2
  QBOW = ENBFAN*FG1(PBARB,NPTSB,PBOW,QB,IB)/BRAT
  QMAIN = ENMFAN*FG1(PBARM,NPTSM,PM,QM,IM)/EMRAT
  QSTN = ENSFAN*FG1(PBARS,NPTSS,PS,QS,IS)/SRAT
  QIN = QBOW+QMAIN+QSTN
  MB1 = (QBOW/ENBFAN+5.0)/5.0
  MB2 = MB1+1
  MB3 = MB2+1
  BINC = ((QBOW/ENBFAN+5.0)-MB1*5.0)/5.0
  BFANHP = ((HP(MB3)-HP(MB2))*BINC+HP(MB2))*ENBFAN*(1./BRAT)**3.0
  MS1 = (QSTN/ENSFAN+5.0)/5.0
  MS2 = MS1+1
  MS3 = MS2+1
  STINC = ((QSTN/ENSFAN+5.0)-MS1*5.0)/5.0
  SFANHP = ((HP(MS3)-HP(MS2))*STINC+HP(MS2))*ENSFAN*(1./SRAT)**3.0
  MM1 = (QMAIN/ENMFAN+5.0)/5.0
  MM2 = MM1+1
  MM3 = MM2+1
  PLINC = ((QMAIN/ENMFAN+5.0)-MM1*5.0)/5.0
  PFANHP = ((HP(MM3)-HP(MM2))*PLINC+HP(MM2))*ENMFAN*(1./EMRAT)**3.0
  RELPWR = PFANHP+BFANHP+SFANHP
  FANPWR = (QBOW*PB1+QMAIN*PB2+QSTN*PB3)/550.
  FANEFF = FANPWR/RELPWR
  IF (IRHS.NE.ON) RETURN
  WRITE (6,3) QBOW,QMAIN,QSTN,PBARB,PBARM,PBARS,RELPWR,FANPWR,FANEFF
C
3 FORMAT (//4H FAN/32H Q - BOW,MAIN,STERN (CU FT /SEC)3F12.1/28H DEL
 1P - BOW,MAIN,STERN (PSF)3F11.2/60H ACTUAL FAN POWER REQUIRED(HP),
 2IDEAL FAN POWER, EFFICIENCY 3F12.4)
C
  RETURN
  END


C
  SUBROUTINE COLFIL
C
  COMMON/AXIS/NXYS(26)
  COMMON/COLUMN/IVERT,ILATRL
```

```
      CCMMON /CURVE/NCURV(10)
      COMMON/EQNCO/ NEQS,TOL(20),JQQ
      COMMON/GRAF/NGRAF,NDRW
      CCMMON /HEADG/TICRD(6)
      CCMMON /PROMOD/ PROMO1,PROMO2,PROMO3,PROMO4,PROMO5,PROMO6,PROMO7
      CCMMON/STEP/ STEP2
      COMMCN /SUM/ ISUM1(8),ISUM2(8)
      REAL*8 TICRD
      REAL LABEL
      REAL LAB(4)/'    ','   1','   2','   3'/
      REAL*8 NAMES(52)/'TIME    ','        ','WAVE HEI','GHT     ','Z DI
     1SPLA','CEMENT  ','PITCH AN','GLE     ','PLENUM P','RESSURE ','BOW 
     2ACCE' ,'LERATION','C.G.ACCE','LERATION','FAN POWE','R(IDEAL)','ROL
     3L ANG','LE      ','YAW ANGL','E       ','LAT ACCE','LERATION','SPE
     4ED TH','RU WATER','TURN RAD','IUS     ','PLENUM V','OLUME   ','X D
     5ISPLA','CEMENT  ','Y DISPLA','CEMENT  ','AIR FLOW',' IN     ','AIR
     6 FLOW',' OUT    ','NET FORC','E X DIR ','WAVE FOR','CE X DIR','THR
     7UST S','TARBOARD','THRUST P','ORT SIDE','  PITCH ','RATE    ','
     8ROLL ','RATE    ','   YAW  ','RATE    ','RUDDER A','NGLE    '/
      REAL*8 TITLE(12)
      REAL*8 LINE2(2)/'PLOT IS ',' VERSUS '/
      REAL*8 NAMEX(2),NAMEY(2),INAME(16)
      EQUIVALENCE (TITLE(1),TICRD(1)),(TITLE(2),TICRD(2)),(TITLE(3),TI
     1CRD(3)),(TITLE(4),TICRD(4)),(TITLE(5),TICRD(5)),(TITLE(6),TICRD(
     26))
      DIMENSION PVQQ(26),XOUT(900),YOUT(900),AFILE(8)
      DIMENSION THSTS(1), THSTP(1)
      EQUIVALENCE (PVQQ(1),TIME),(PVQQ(2),ETA),(PVQQ(3),Z),(PVQQ(4),THET
     1A),(PVQQ(5),PB),(PVQQ(6),BOWACC),(PVQQ(7),ACC),(PVQQ(8),FANPWR),(P
     2VQQ(9),PHI),(PVQQ(10),BETAS),(PVQQ(11),ACCLAT),(PVQQ(12),U),(PVQQ(
     313),TRADUS),(PVQQ(14),VOLP),(PVQQ(15),X),(PVQQ(16),Y),(PVQQ(17),QI
     4N),(PVQQ(18),QOUT),(PVQQ(19),GFXXX),(PVQQ(20),FXPWAV),(PVQQ(21),TH
     5STS(1)),(PVQQ(22),THSTP(1)),(PVQQ(23),QDEG),(PVQQ(24),PDEG),(PVQQ(
     625),RDEG),(PVQQ(26),DELRS)
C
      IF(JQQ.NE.2) GO TO 1
      WRITE(6,777) STEP2
  777 FORMAT('0',4X,'THIS RUN USED VARIABLE STEP SIZE',/,'0',4X,'THE MIN
     1IMUM STEPSIZE RECORDED DURING THE RUN WAS',2X,E30.5)
    1 ENDFILE 1
      REWIND 1
      TITLE(7)=LINE2(1)
      TITLE(10)=LINE2(2)
      IF(NGRAF.EQ.0) GO TO 11
      J=1
      NGF=NGRAF
      INDEX=NGRAF*2
      DO 19 I=1,INDEX,2
```

```
      INDX=NXYS(I)                                                      CFL 0540
      INDY=NXYS(I+1)                                                    CFL 0550
      IQ=0                                                              CFL 0560
    7 READ(1,END=8)TIME,ETA,Z,THETA,PB,BOWACC,ACC,FANPWR,PHI,BETAS,ACCLACFL 0570
     1T,U,TRADUS,VOLP,X,Y,QIN,QOUT,GFXXX,FXPWAV,THSTS(1),THSTP(1),QDEG, CFL 0580
     2PDEG,RDEG,DELRS                                                   CFL 0590
      IF(IQ.GE.900) GO TO 8                                             CFL 0600
      IQ=IQ+1                                                           CFL 0610
      XOUT(IQ)=PVQQ(INDX)                                               CFL 0620
      YOUT(IQ)=PVQQ(INDY)                                               CFL 0630
      GO TO 7                                                           CFL 0640
    8 REWIND 1                                                          CFL 0650
      INX=INDX*2                                                        CFL 0660
      INY=INDY*2                                                        CFL 0670
      NAMEX(1)=NAMES(INX-1)                                             CFL 0680
      NAMEX(2)=NAMES(INX)                                               CFL 0690
      NAMEY(1)=NAMES(INY-1)                                             CFL 0700
      NAMEY(2)=NAMES(INY)                                               CFL 0710
      IF(NDRW.EQ.1) GO TO 20                                            CFL 0720
C                                                                       CFL 0730
      CALL PLOTP(XOUT,YOUT,-IQ,0)                                       CFL 0740
C                                                                       CFL 0750
      WRITE(6,301) NAMEX,NAMEY                                          CFL 0760
  301 FORMAT(' ',20X,2A8,' IS THE INDEPENDENT VARIABLE AND ',2A8,' THE DCFL 0770
     1EPENDENT VARIABLE')                                               CFL 0780
      GO TO 19                                                          CFL 0790
   20 TITLE(8)=NAMEY(1)                                                 CFL 0800
      TITLE(9)=NAMEY(2)                                                 CFL 0810
      TITLE(11)=NAMEX(1)                                                CFL 0820
      TITLE(12)=NAMEX(2)                                                CFL 0830
      NCUR=NCURV(J)                                                     CFL 0840
      IF(NCUR.NE.0) GO TO 25                                            CFL 0850
      LABEL=LAB(1)                                                      CFL 0860
C                                                                       CFL 0870
      CALL DRAW(IQ,XOUT,YOUT,NCUR,0,LABEL,TITLE,0,0,0,0,0,0,8,8,0,LAST) CFL 0880
C                                                                       CFL 0890
      J=J+1                                                             CFL 0900
      GO TO 19                                                          CFL 0910
   25 WRITE(2)IQ,NCUR,NGF,LABEL,(TITLE(K),K=1,12),(XOUT(L),YOUT(L),L=1,ICFL 0920
     1Q)                                                                CFL 0930
      NGF=NGF-1                                                         CFL 0940
   19 CONTINUE                                                          CFL 0950
      IF((NGF.EQ.0).AND.(NCUR.EQ.3)) GO TO 26                           CFL 0960
   11 IF(IVERT.NE.1) GO TO 14                                           CFL 0970
      WRITE(6,100)                                                      CFL 0980
  100 FORMAT('0',50X,'***SUMMARY ONE***',/,'0')                         CFL 0990
      K=0                                                               CFL 1000
      DO 31 I=1,8                                                       CFL 1010
```

```
      IF(ISUM1(I).NE.0) K=K+1
   31 CONTINUE
      NUM1=K
      IF(K.EQ.0) GO TO 14
      N=K*2
      J=1
      DO 33 I=1,NUM1
      IDEX=ISUM1(I)*2
      INAME(J)=NAMES(IDEX-1)
      INAME(J+1)=NAMES(IDEX)
      J=J+2
   33 CONTINUE
       WRITE(6,300)(INAME(I),I=1,N)
  300 FORMAT('0',16A8)
      GO TO 4
   26 ENDFILE 2
      REWIND 2
      NGF=NGRAF
      J=1
   27 READ(2,END=38)IQ,NCUR,NGRAF,LABEL,(TITLE(K),K=1,12),(XOUT(L),YOUT(
     1L),L=1,IQ)
      IF((NGF.EQ.NGRAF).AND.(NCUR.EQ.J)) GO TO 29
      GO TO 27
   29 LABEL=LAB(J+1)
C
      CALL DRAW(IQ,XOUT,YOUT,NCUR,0,LABEL,TITLE,0,0,0,0,0,0,8,8,0,LAST)
C
      REWIND 2
      J=J+1
      IF(J.EQ.4) GO TO 38
      GO TO 27
   38 NGF=NGF-1
      IF(NGF.EQ.0) GO TO 11
      J=1
      GO TO 27
    4 READ(1,END=13)(PVQQ(I),I=1,26)
      DO 35 I=1,NUM1
      J=ISUM1(I)
   35 AFILE(I)=PVQQ(J)
      WRITE(6,400)(AFILE(I),I=1,NUM1)
  400 FORMAT('0',8(3X,F10.2,3X))
      GO TO 4
   13 REWIND 1
   14 IF(ILATRL.NE.1) GO TO 17
      WRITE(6,200)
  200 FORMAT('0',50X,'***SUMMARY TWO***',/,'0')
      K=0
      DO 32 I=1,8
```

```
      IF(ISUM2(I).NE.0) K=K+1                                           CFL 1500
   32 CONTINUE                                                          CFL 1510
      NUM2=K                                                            CFL 1520
      IF(K.EQ.0) GO TO 16                                               CFL 1530
      N=K*2                                                             CFL 1540
      J=1                                                               CFL 1550
      DO 34 I=1,NUM2                                                    CFL 1560
      IDEX=ISUM2(I)*2                                                   CFL 1570
      INAME(J)=NAMES(IDEX-1)                                            CFL 1580
      INAME(J+1)=NAMES(IDEX)                                            CFL 1590
      J=J+2                                                             CFL 1600
   34 CONTINUE                                                          CFL 1610
       WRITE(6,300)(INAME(I),I=1,N)                                     CFL 1620
   23 READ(1,END=16)(PVQQ(I),I=1,26)                                    CFL 1630
      DO 36 I=1,NUM2                                                    CFL 1640
      J=ISUM2(I)                                                        CFL 1650
   36 AFILE(I)=PVQQ(J)                                                  CFL 1660
      WRITE(6,400)(AFILE(I),I=1,NUM2)                                   CFL 1670
      GO TO 23                                                          CFL 1680
   16 REWIND 1                                                          CFL 1690
   17 RETURN                                                            CFL 1700
      END                                                               CFL 1710
C                                                                       SAM 0010
      SUBROUTINE SAM                                                    SAM 0020
C                                                                       SAM 0030
      WRITE (6,10)                                                      SAM 0040
   10 FORMAT (1H1,'YOU HAVE CALLED A DUMMY SAM SUBROUTINE.'/            SAM 0050
     110X,'CHANGE TO BHISES TO USE THE SAM SUBROUTINE.')                SAM 0060
      RETURN                                                            SAM 0070
      END                                                               SAM 0080
C                                                                       T1  0010
      FUNCTION T1(X)                                                    T1  0020
C                                                                       T1  0030
      IF(ABS(X)-.1) 10,10,20                                            T1  0040
 10   T1=X*(1.-X*X/10.0)/3.                                             T1  0050
      RETURN                                                            T1  0060
 20   T1=(SIN(X)-X*COS(X))/(X*X)                                        T1  0070
      RETURN                                                            T1  0080
      END                                                               T1  0090
C                                                                       T2  0010
      FUNCTION T2(X)                                                    T2  0020
C                                                                       T2  0030
```

```
      IF(ABS(X)-.1) 10,10,20
10    T2=1.-X*X/6.
      RETURN
20    T2=SIN(X)/X
      RETURN
      END
```

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Study of the roll and pitch transients in calm water using the simulated performance of the XR-3 surface effect ship loads and motions computer program.